cea leti

Micro & nano-technologies for health

Human, animal, and environnemental health

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Research for industrial innovation

The healthcare of tomorrow: technologies and innovations for all, everywhere.

In response to the evolving healthcare needs driven by an aging population, the health impacts of climate change, and the growing pressure on healthcare systems, a new approach is essential. At CEA-Leti, we firmly believe that microtechnologies and digital innovation can deliver transformative solutions that serve humanity. Every day, our teams develop concrete advancements: smart sensors, AI-assisted diagnostic devices, personalized medicine, neurotechnologies, and more. These innovations are designed to enhance quality of life, anticipate diseases, and promote autonomy.

Our "lab-to-market" approach bridges the gap between scientific breakthroughs and robust, accessible technologies. By fostering strong collaboration between research, industry, and healthcare professionals, we accelerate large-scale deployment for the benefit of all. Our commitment also extends to a sustainable vision of healthcare.

Guided by the "One Health" approach which connects human, animal, and environmental health we shape our innovation strategy to be global, responsible, and enduring.

Together with our industrial, academic, and clinical partners, we are building a unique ecosystem to address tomorrow’s challenges. We believe technology holds its greatest value when it serves health.

This second edition underscores our dedication to creating a more human-centered, preventive, inclusive, and forward-looking healthcare system.

Sébastien Dauvé
CEO, CEA-Leti

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At the forefront of technologies for the medicine of the future

The healthcare sector relies on innovative technologies to prevent and predict diseases, improve medical diagnostics, enhance biotherapy production, and better monitor and treat patients. With its multidisciplinary expertise—microelectronics, biology, physics, chemistry, artificial intelligence, and more... CEA-Leti drives this transformation by developing industrial-scale solutions, some of which are world firsts.

The pace of these innovations has accelerated in recent years. In 2023, CEA-Leti, in collaboration with the École Polytechnique Fédérale de Lausanne, announced a groundbreaking achievement: a "digital bridge" enabling a paraplegic individual to walk using a walker, controlling their movements through thought.

In 2024, another milestone was reached: CEA-Leti published research in *Nature Communications* on culturing and vascularizing organoids on a microfluidic chip.

Other cutting-edge projects aim to slow the progression of Parkinson's disease using an intracerebral implant that emits infrared light. Additionally, CEA-Leti supports bioproduction industries with technological innovations designed to optimize drug manufacturing, improve quality control, and expand patient access.

4 Application domains

Technologies for the medicine of the future are one of the four major research axes for the 20,000 CEA engineers and researchers. At CEA-Leti, work spans four key areas:

Medical imaging technologies

Toward more precise and "portable" X-ray and gamma imagers for bedside patient deployment

Tools for pharmaceuticals and biotechnologies

A priority—developing tools to optimize the production and analysis of biomedicines

Technologies for innovative medical devices

Improving diagnosis, monitoring, and treatment of diseases with miniaturized wearable or implantable devices

Prevention and well-being

Monitoring and tracking systems that enhance quality of life and well-being

→ **Linking human, animal, and environmental health**

CEA-Leti aligns with the "One Health" initiative launched in 2010, notably by the WHO and UNEP*. One Health works in a coordinated manner on three interdependent areas: human health, animal health, and environmental health.

60% of human infectious diseases originate from animals. Human pandemics and zoonoses are interconnected and cannot be addressed separately.

→ **Over 350 active patents**

The technological foundation of CEA-Leti's health innovations includes microelectronics, optics, photonics, algorithms, AI, sensors, actuators, imagers, electronic systems, communication, and energy efficiency of devices. These expertise areas interface with life sciences through additional specialties such as biomaterials, microfluidics, and sample preparation. Advances are protected by over 350 active patents.

Health research accounts for more than 10% of CEA-Leti's activities. It is equally driven by an applied department (the Department of Technologies for Health Innovation) and four expert departments in silicon technologies, optics, electronic components, system approaches, telecommunications, and energy management.

Additionally, CEA-Leti operates Clinatec, a one-of-a-kind biomedical research center: a clinical sector with six rooms, an operating theater, intraoperative MRI, magnetoencephalography (MEG), a scanner, and more.

→ **Promoting startup creation**

To achieve strong societal impact, create jobs, and contribute to French and European sovereignty in health, CEA-Leti fosters industrial partnerships and transfers its technologies to biotechnology companies, pharmaceutical laboratories, and medical equipment manufacturers. It collaborates with major industry players such as Sanofi, Ceva, Onward Medical, Thales, and Trixell.

The dissemination of technologies also involves the creation of spin-out start-ups from its research, often led by former research engineers. Examples include: Fluoptics (surgical guidance), Avalun (point-of-care diagnostics), Mag4Health (magnetoencephalography), Admir (cancer diagnostics), Injectpower (microbatteries for medical implants), Remedee Labs (pain treatment), Nawu Diagnostics (veterinary diagnostics).

**UNEP: United Nations Environment Programme*

Medical imaging technologies

Reinventing the care pathway

Toward more accessible and efficient X-ray imaging exams

Many healthcare systems face two major challenges that may seem contradictory. On one hand, there is the issue of access to care in medical deserts, which requires the development of mobile and agile diagnostic solutions. On the other hand, there is the growing demand for precision medicine, which calls for cutting-edge, personalized diagnostic and therapeutic approaches for each patient.

Medical imaging, a source of major innovations, holds remarkable potential to address these challenges—both by advancing portable imaging and by developing precision imaging based on advanced technologies and theranostics.

The era when imaging exams could only be performed in hospitals or specialized centers will soon be over: X-ray sources are being miniaturized, and imaging systems are becoming lighter and more compact for mobility. They aim to reach health centers, medical deserts, and nursing homes to enable earlier diagnoses, provide faster patient care, strengthen preventive measures, and reduce the strain on radiology services.

These portable imaging devices seek to transform care pathways, offering high-quality, in-depth imaging through reconstruction without the need to transport fragile patients to a scanner.

CEA-Leti plays a key role in deploying these disruptive technologies: it develops silicon technology to miniaturize X-ray sources, reinvents interventional radiology with new spectral detectors to improve diagnostic precision while reducing patient radiation dose, and prepares the next generation of photon-counting scanners. At the same time, it enhances the sensitivity performance of positron gamma imaging for greater patient comfort, opening up prospects for simultaneous multi-isotope imaging (diagnostic and theranostic).

Medical imaging

INDUSTRIAL TRANSFER UNDERWAY

Nuclear medicine: innovative semiconductor materials for optimized exams

Thanks to an innovative, compact, and low-cost detection module, it is now possible to perform gamma SPECT imaging as quickly as with a positron emission tomograph, but with superior image quality and a wider range of radiotracers. This means greater comfort for patients and new potential applications.

«

We collaborate with gamma-ray system manufacturers to develop prototyping capabilities, taking into account the mass production constraints of future products. CEA-Leti is able to ensure rapid technology transfers and reduced time-to-market, thanks in part to its rigorous and clear patent policy. »

Loïck Verger,
Senior medical imaging expert,
CEA-Leti

→ **See also:**
NuVISION: a portable multimode gamma camera based on HiSPECT imaging module
youtu.be/ullyQMktAUA

→ How does it work?

To compete with positron emission tomography (PET), single-photon emission computed tomography (SPECT) imaging must overcome its sensitivity deficit. CEA-Leti has achieved this with a CdZnTe semiconductor-based detection module that reconciles two seemingly incompatible requirements: high spatial resolution, which requires small pixels, and high energy resolution, which requires larger pixels.

This breakthrough is made possible by a revolutionary signal processing innovation, derived from an ultra-low-noise readout circuit: each detected photon, measured for energy, is localized in 3D within the module, and its industrial transfer is underway. This opens up prospects for simultaneous multi-isotope imaging, particularly in theranostics, which involves simultaneously identifying and treating cancerous lesions.

→ What are the advantages?

The compactness, modularity, and performance level of the detection module pave the way for SPECT imaging systems with ultra-high-sensitivity collimators (two orders of magnitude superior to commercial cameras). Additionally, they significantly reduce the duration of medical scans for greater patient comfort and open up possibilities for simultaneous multi-isotope imaging (diagnostic and theranostic).

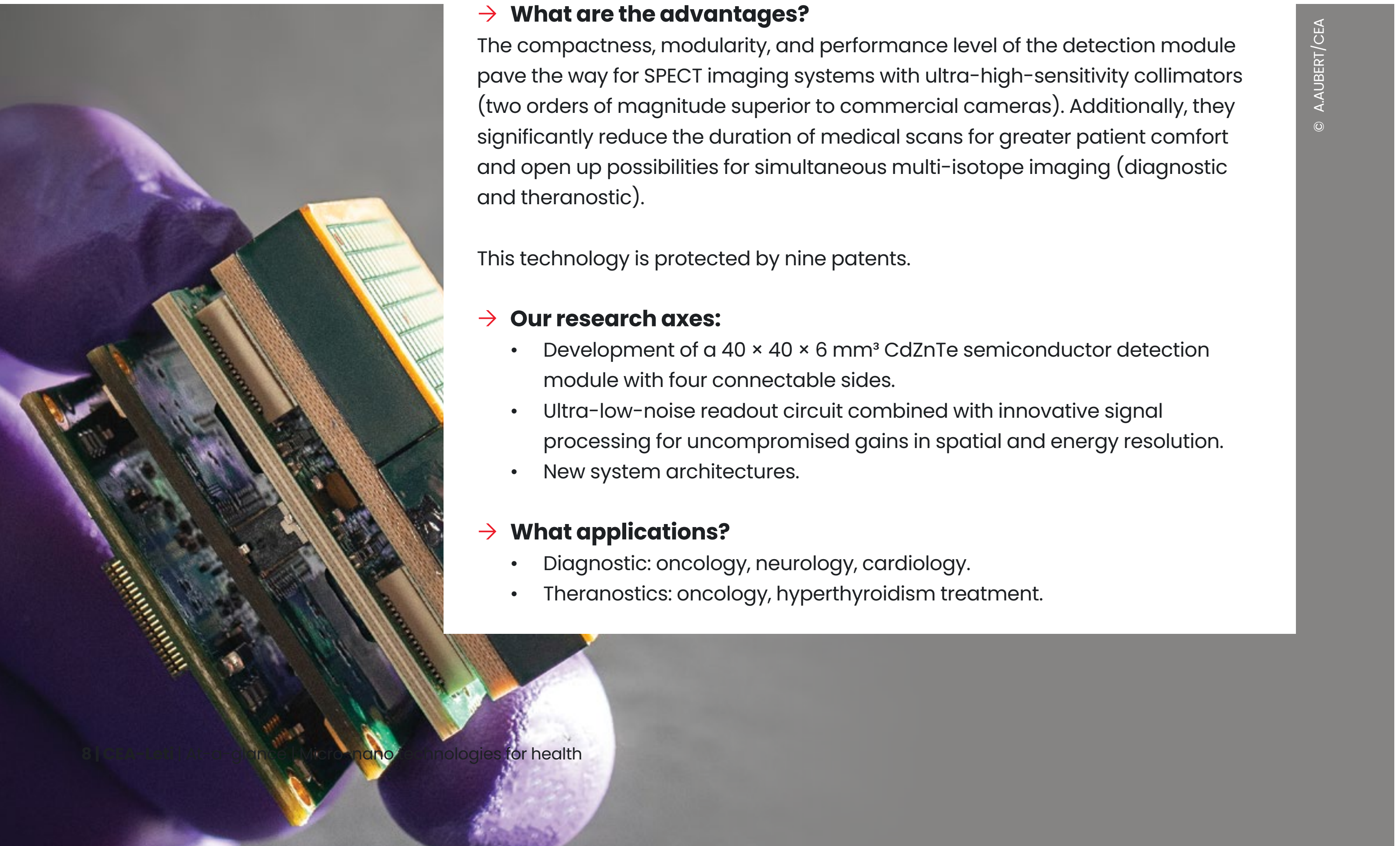
This technology is protected by nine patents.

→ Our research axes:

- Development of a 40 × 40 × 6 mm³ CdZnTe semiconductor detection module with four connectable sides.
- Ultra-low-noise readout circuit combined with innovative signal processing for uncompromised gains in spatial and energy resolution.
- New system architectures.

→ What applications?

- Diagnostic: oncology, neurology, cardiology.
- Theranostics: oncology, hyperthyroidism treatment.



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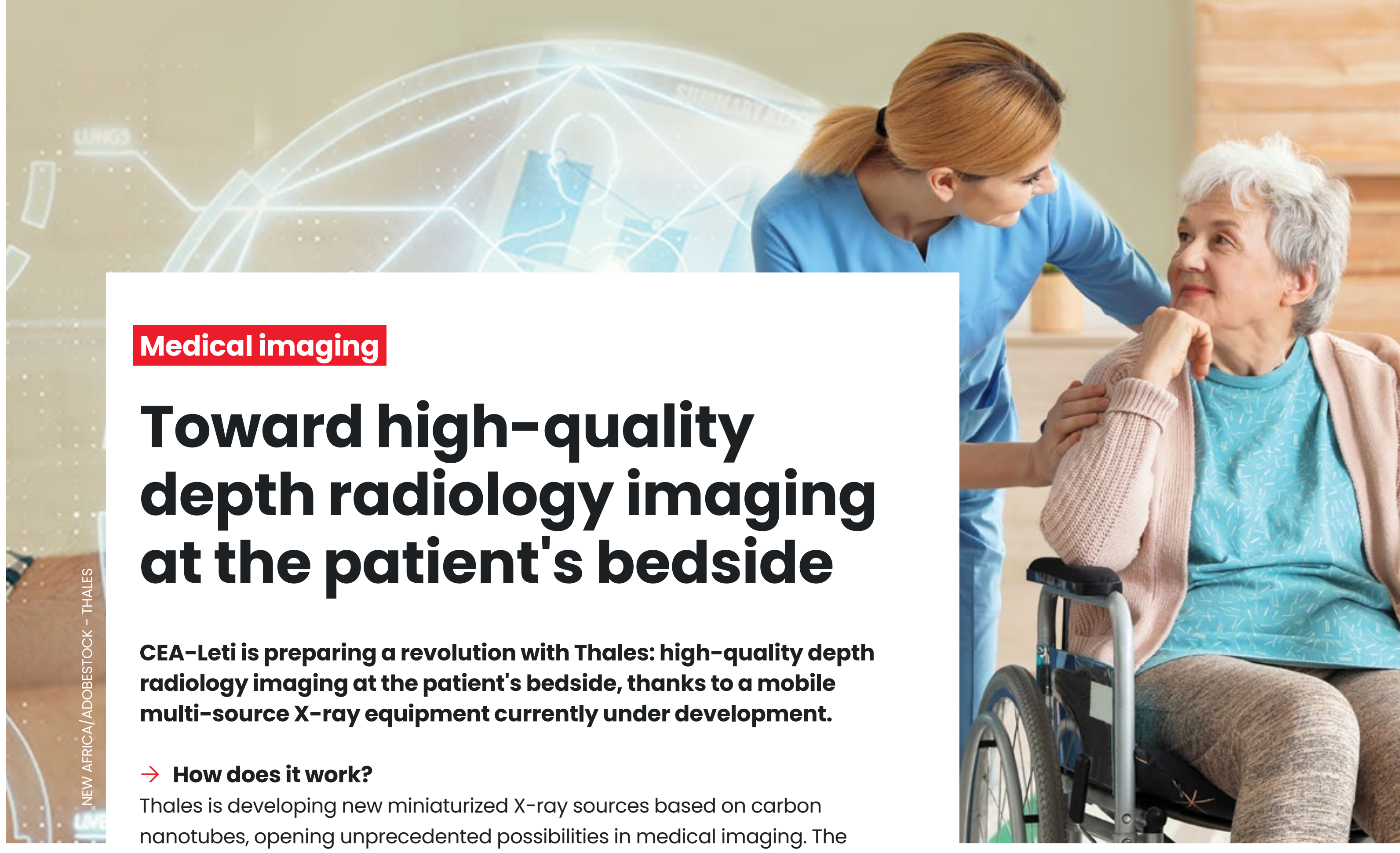


NEW AFRICA/ADOBESTOCK - THALES

Medical imaging

Toward high-quality depth radiology imaging at the patient's bedside

CEA-Leti is preparing a revolution with Thales: high-quality depth radiology imaging at the patient's bedside, thanks to a mobile multi-source X-ray equipment currently under development.

→ How does it work?

Thales is developing new miniaturized X-ray sources based on carbon nanotubes, opening unprecedented possibilities in medical imaging. The principle involves generating 2D stereoscopic images using multiple sources, which, after algorithmic reconstruction, produce a depth radiographic image.

Using its simulation tool, CEA-Leti has designed the architecture of the radiology system, integrating the entire imaging chain—from the characteristics of the multi-sources to the development of reconstruction and image correction algorithms. This ensures optimal depth radiographic image quality based on a limited number of views, while meeting the geometric precision constraints specific to this mobile system.

Thanks to its expertise in silicon technologies, CEA-Leti has also developed the silicon substrates on which Thales will grow the carbon nanotubes required for this disruptive innovation.

→ What are the advantages?

The depth radiographic imaging system through reconstruction will reveal what "a conventional X-ray hides through overlap," without the need to transport fragile patients to a scanner. This will help reduce the strain on radiology services.

→ Our research axes:

- Simulation of the imaging chain and system sizing.
- Reconstruction and image correction algorithms.
- Silicon process for carbon nanotube growth.

→ What applications?

- Depth imaging through algorithmic reconstruction for diagnosis.

«

The depth radiology imaging system through reconstruction, currently under development, paves the way for new hospital care strategies. We have transferred key elements of this technology to Thales, which will contribute to reviving a sovereign French medical imaging industry. »

Loïck Verger,
Senior medical imaging expert,
CEA-Leti

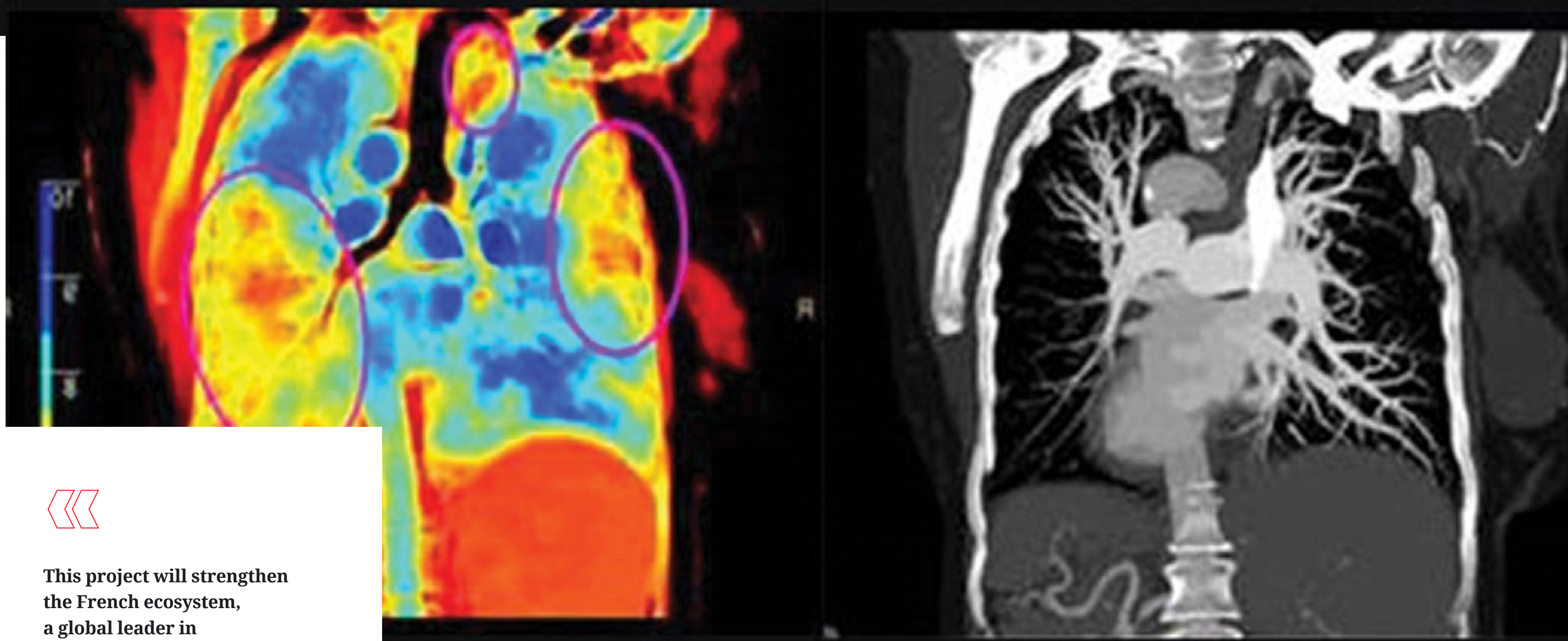
→ **With the support of:**

THALES

Interventional radiology

3D color images in real time for interventional radiology

The ImaSpiiR-X consortium, which includes the CEA, aims to provide clinicians with information on tissue density and composition for the emergency management of strokes (CVA) or cancer surgery. The key to this advancement lies in new generations of flat X-ray sensors and advanced algorithms.



→ How does it work?

The ImaSpiiR-X consortium brings together five French partners. Their goal is to develop, over five years (2025–2030), next-generation spectral flat sensors that will provide enriched digital radiographic images and advanced analysis algorithms. They rely on an international team of medical experts and leverage complementary expertise in materials, semiconductors, electronics, and algorithms, with disruptive technologies serving the medical community.

CEA is tasked with developing this new generation of detectors to:

- Improve image quality and sensitivity to reduce patient radiation dose.
- Enhance diagnostic precision and pave the way for multi-contrast agent imaging for more personalized treatment.

→ What are the advantages?

While today's black-and-white medical imaging only provides information on tissue density, spectral color imaging will also identify tissue composition, assisting surgeons during procedures. This could save precious minutes in stroke management (2 million neurons are lost every minute) or better guide surgeons operating on cancer.

→ Our research axes:

- Development of high-sensitivity spectral flat sensors.
- Associated processing algorithms.

→ What applications?

- Stroke: faster and more accurate diagnosis, guidance for clinical procedures.
- Cancer surgery: better discrimination of malignant areas, even deep within organs.

«

This project will strengthen the French ecosystem, a global leader in interventional radiology and real-time image-guided surgery, while improving the quality of care for patients. The flat sensors resulting from this collaboration will be manufactured in France, with the majority of supplies sourced from over 200 French providers. »

Loïck Verger,
Senior medical imaging expert,
CEA-Leti

→ With the support of:

Technologies for innovative medical devices

cea leti

Toward a revolution in diagnosis and management of diseases

Microtechnologies and artificial intelligence are transforming the prevention, treatment, monitoring, and even progression of diseases.

CEA-Leti offers technologies for three types of medical devices: in vitro devices, wearable devices, and implanted devices, as well as decision-support software, contributing to the transformation of the healthcare model. The goals are to leverage semiconductor technologies and CEA-Leti's multidisciplinary teams to develop industrial-scale devices with high performance and robustness, while conducting R&D in compliance with medical device regulations.

By providing data that can be directly used by healthcare professionals and/or patients, the advent of innovative sensors integrated into systems opens up unprecedented possibilities:

- **Diagnosing and continuously monitoring** diseases at the patient's bedside, alerting on the evolution of critical physiological parameters.
- **Restoring** motor functions through innovative brain-machine interfaces.
- **Slowing the progression** of Parkinson's disease by illuminating the part of the brain affected by degeneration. A unique clinical trial is underway to evaluate this revolutionary therapeutic approach.

SUCCESS STORY: ONWARD MEDICAL

This technology has been transferred to ONWARD Medical to develop and eventually commercialize the ARCBCI digital bridge. This agreement gives ONWARD Medical the opportunity to be the first to market with a BCI-activated system to restore thought-guided movement after paralysis.

→ See also:

Walking naturally after spinal cord injury using a brain–spine interface. Lorach, H., et al. (2023). Nature 618 doi: 10.1038/s41586-023-06094-5

An exoskeleton controlled by an epidural wireless brain–machine interface in a tetraplegic patient: a proof-of-concept demonstration. Benabid, A.-L., et al. (2019). The Lancet Neurology 18.12

Implantable devices

The WIMAGINE® BCI technology confirms its potential in neurohabilitation

Through several clinical trials, CEA-Leti and its partners are exploring the potential of brain-machine interface technology for motor assistance and therapy.

→ How does it work?

WIMAGINE® is a unique brain-machine interface technology based on an implant that records brain activity on the surface of the motor cortex, combined with dedicated artificial intelligence algorithms for decoding the movement intentions of patients with motor disabilities. It enables control of functional substitution effectors, helping patients regain better mobility to perform daily tasks.

→ What are the advantages?

WIMAGINE® has already contributed to two world firsts published in *The Lancet Neurology* and *Nature.* In 2019, a tetraplegic patient was able to use his brain activity to control a four-limb exoskeleton. In 2023, a patient with incomplete paraplegia regained natural control of his walking thanks to the combination of CEA's WIMAGINE® technology with a spinal cord stimulation therapy developed by EPFL/CHUV/UNIL/ONWARD Medical (Lausanne, Switzerland). Through a digital bridge between the brain and the spinal cord, the patient was able to control the amplitude of his steps directly from his brain activity, allowing him to walk on complex terrain and even climb stairs.

The WIMAGINE® technology is protected by 25 patents.

→ Our research axes:

- Miniaturizing WIMAGINE® technology to facilitate daily use, through targeted advances in portability, autonomy, and ergonomics.
- Designing embedded, precise, and robust BCI decoding algorithms for implementation on integrated circuits.
- Developing a new generation of neuroprostheses, opening the way to new therapeutic perspectives.

→ What applications?

- **Functional compensation** for severe motor deficits.
- **Communication tools** (virtual keyboard or web service, voice synthesizer, etc.) for patients with communication disorders resulting from neurological conditions such as locked-in syndrome, aphasia, etc.
- **Neurorehabilitation therapies**, complementing traditional rehabilitation methods for patients with neurological deficits, such as those caused by stroke.

This work was supported by the Climatec Fund and its patrons (WIMAGINE® implant), the Carnot CEA-Leti Institute, CEA (recurrent funding), Horizon Europe—European Innovation Council (EIC), Leenaards Foundation, the French National Research Agency (ANR), the Swiss National Science Foundation (SNF), and the Ministry of Health.

GILLES WEBER/CHUV

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Implantable devices

Slowing the progression of Parkinson's disease with light

There are only symptomatic treatments available for the 10 million people worldwide living with Parkinson's disease. The Grenoble-Alpes University Hospital, in close collaboration with CEA-Leti*, is conducting a clinical trial to evaluate a solution that could slow its progression: an intracerebral implant whose light emission would protect neurons.

→ How does it work?

The light emission from a laser diode operating at 670 nm (in the red color range) is guided via an optical fiber to the substantia nigra of the brain, where neuronal cells degenerate during Parkinson's disease. The diode is positioned in a 2.5 cm diameter electronic housing placed in the cranial box, replacing the bone, during a surgical procedure. The optical fiber is then surgically inserted through the brain's natural cavities, making the implant minimally invasive.

→ What are the advantages?

The therapeutic effect of light has been demonstrated by several studies on rodent and non-human primate Parkinson's models**.

Following these preclinical studies, CEA-Leti* carried out the technological development of the implant and filed 15 patents. It initiated the world's first clinical trial, coordinated by Clinatec, with 14 patients included (7 implanted patients and 7 control patients). Four years after the first implantation, the initial clinical results are encouraging.

→ Our research axes:

- Understanding the mechanism of action of light on neurons.
- Designing a new implant to facilitate a future large-scale clinical study.

→ What applications?

- Treatment of Parkinson's disease.
- Evaluation of the technique's adaptability to other pathologies such as Alzheimer's disease and Huntington's disease: a preclinical research project funded by the ANR began in 2024.

**In collaboration with Boston Scientific.*

***This work was supported by the Carnot CEA-Leti Institute, CEA (recurrent funding), the Clinatec Fund and its patrons, France Parkinson, the Fondation de l'Avenir, and the Michael J. Fox Foundation.*

«

Preliminary results from the clinical trial encourage us to continue developing this technology. We are particularly looking to simplify the surgery and reduce the implant's power consumption to increase battery life and allow patients to forget the presence of this intracerebral device. »

Mathieu Perriollat,
LEDI Project manager, CEA-Leti

→ See also:

Near-infrared light is neuroprotective in a monkey model of Parkinson's disease. Darlot, F. et al. (2016) Ann Neurol. 79. doi: 10.1002/ana.24542

Intracranial photobiomodulation in de novo Parkinson's patients: preliminary data of an ongoing randomized controlled trial . Chabardès, S. et al. (2025). doi.org/10.1101/2025.01.23.25320819

Microbatteries

A rechargeable microbattery for continuous intraocular pressure monitoring

For patients at risk of glaucoma, continuously monitoring intraocular pressure is far more effective than relying solely on periodic medical check-ups. InjectPower has developed a rechargeable microbattery small enough to be inserted into the eye to power an associated MEMS pressure sensor.

SUCCESS STORY: INJECTPOWER

The start-up InjectPower was created in 2020 to industrialize and commercialize rechargeable microbatteries. It has its own factory, located a few kilometers from CEA-Leti, equipped with 1,500 m² of 200 mm cleanrooms. By 2029, it will be able to manufacture millions of products per year.

As an associated partner in the IPCEI Tech4Cure health project, InjectPower will participate in a European initiative that places energy at the heart of the revolution in implantable medical devices.

→ How does it work?

The microbattery uses all-solid-state lithium-ion technology. It is manufactured using 200 mm microelectronics equipment through successive layer deposition. Its high power density (five times that of competing products) provides a one-week autonomy under normal use, and it recharges via inductive coupling.

It measures 1.8 mm × 0.85 mm, with a thickness of 0.1 mm. It is paired with a MEMS pressure sensor, control electronics, and a wireless communication system to transfer data. The entire system is installed in the eye through a tiny incision.

→ What are the advantages?

The creation of the start-up InjectPower is the result of over 18 years of development at CEA in the field of microbatteries. This long scientific journey has led to the filing of more than 40 patent families, including an exclusive license for medical applications. It is the first microbattery both small enough to be inserted into the eye and energy-dense enough to ensure several days of autonomy. This density can still be improved.

With a volume on the order of 1 mm³, it enables continuous monitoring of relevant biological parameters without patient intervention. This monitoring is far more precise than periodic medical check-ups.

Manufacturing using collective microelectronics processes ensures high-volume production at reduced unit costs.

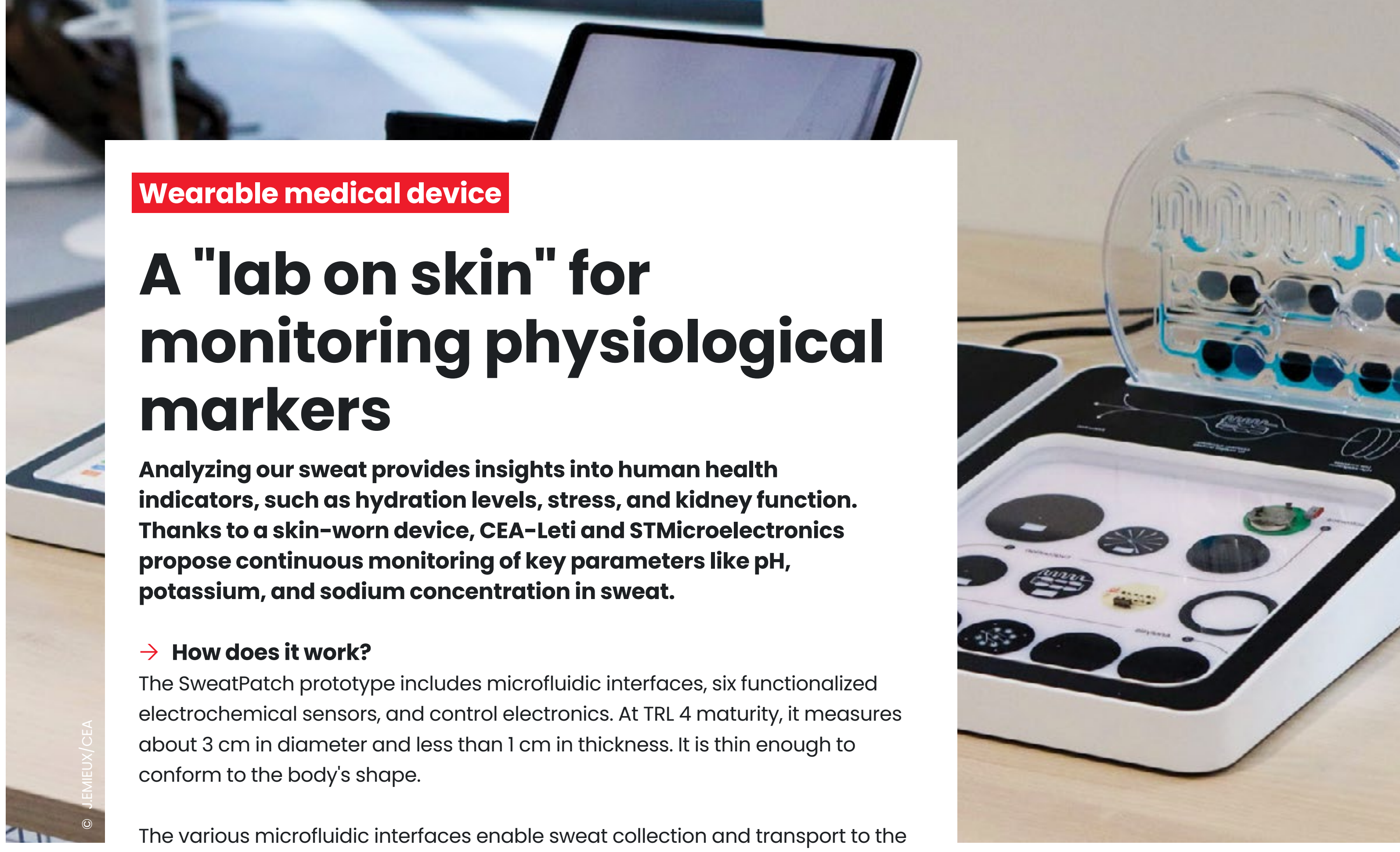
→ Our research axes:

- Improving the cycling and lifespan of microbatteries.
- Optimizing layer deposition steps.
- Optimizing the active surface area/total surface area ratio.
- 3D stacking of microbatteries for higher energy needs.

→ What applications?

- Intraocular pressure monitoring (glaucoma prevention).
- Intracranial pressure monitoring (hydrocephalus, post-stroke monitoring, etc.).
- Cardiology (e.g., pulmonary arterial pressure).

© INJECTPOWER



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Wearable medical device

A "lab on skin" for monitoring physiological markers

Analyzing our sweat provides insights into human health indicators, such as hydration levels, stress, and kidney function. Thanks to a skin-worn device, CEA-Leti and STMicroelectronics propose continuous monitoring of key parameters like pH, potassium, and sodium concentration in sweat.

→ How does it work?

The SweatPatch prototype includes microfluidic interfaces, six functionalized electrochemical sensors, and control electronics. At TRL 4 maturity, it measures about 3 cm in diameter and less than 1 cm in thickness. It is thin enough to conform to the body's shape.

The various microfluidic interfaces enable sweat collection and transport to the sensors, each located in a separate chamber. Depending on the application, the sensors can be functionalized either identically for greater reliability (measurement reproducibility) or differently to enable multi-parameter analysis of sweat composition. Results are transmitted continuously and in real time via wireless communication. The collected sweat is disposed of once measured.

→ What are the advantages?

Tests in climate chambers and during several hours of physical activity have shown that SweatPatch adheres well to the skin, maintaining its initial position without causing irritation or discomfort during intense sports activities. The device is considered lightweight and unobtrusive. The electrochemical measurements are sensitive, stable, and reproducible, and the sweat flow is managed precisely and in a controlled manner.

This technology is protected by 4 patents.

→ Our research axes:

- Maturing the current prototype: microfluidic interface processes, electrochemical sensors, electronics, system integration, pre-industrialization, telecommunications.
- Design, fabrication, and functionalization of electrochemical sensors.
- Addition of new sensors and parameters.
- Field trials and clinical studies with partners.

→ What applications?

- Physiological and pathological diagnosis and monitoring through biological parameter measurements: pH, calcium, lactate, glucose, cortisol, etc.
- Hydration level monitoring: at-risk individuals, at-risk professions, sports or professional training, etc.

«

Beyond our ambition to obtain representative physiological measurements, our device proves highly adaptable, capable of sensitively and reproducibly measuring a wide range of biomarkers while being non-invasive and easily placed on any part of the body: two major advantages for this medical device. »

Yohann Thomas,
Research Engineer,
Electrochemical sensor expert,
CEA-Leti

→ See also:

Press release: *CEA-Leti Worked with STMicroelectronics on Health & Wellness Breakthrough: A Wearable System For Continuous Sweat Monitoring*

→ In partnership with:

Wearable medical device

Miniaturized and low-cost QCL device

Monitoring blood glucose and other biomarkers without having to regularly prick your finger or wear a microneedle patch: this is what CEA-Leti's transcutaneous glucose measurement device offers, based on quantum cascade laser (QCL, excitation) and photoacoustic (PA, detection) technologies.

→ How does it work?

The sensor includes the QCL laser, a cell, and a miniaturized microphone. It is integrated into a wrist-worn bracelet. The laser emits a light wave in the mid-infrared range at a specific wavelength that passes through the skin and excites the molecules associated with the biomarker to be measured. When these molecules relax after excitation, the relaxation produces heat, which in turn generates an acoustic signal that is recorded and analyzed. The signal intensity is related to the biomarker concentration.

The measurement is sensitive and selective because the QCL laser emissions, which are highly targeted in wavelength and strongly absorbed by the molecules, can also be calibrated with high precision.

→ What are the advantages?

Two clinical validation trials, conducted with Grenoble-Alpes University Hospital, have shown very promising performance for non-invasive glucose monitoring, approaching the precision level of reference invasive methods.

QCL lasers currently cost from several hundred to several thousand euros per unit because they are manufactured using low-yield processes. CEA-Leti is developing an alternative manufacturing process for these lasers using silicon-based microelectronics, aiming to reduce the cost by a factor of 100 and make the technology more accessible. This research on QCL lasers is protected by about fifteen patents.

→ Our research axes:

- Improve the QCL laser manufacturing process by transferring III-V structures onto silicon.
- MEMS technologies for capturing and recording acoustic waves.
- System integration.
- Prediction algorithms and machine learning.
- Reducing measurement variability.

→ What applications?

- Well-being and prevention: glucose monitoring (e.g., for diabetic individuals) and other biomarkers for sports.
- Rapid diagnosis of medical samples: micro-bacteriology, analysis of potentially cancerous tissues.
- Water analysis and processing monitoring.

«

The performance of QCL lasers is established, but the cost of the components is currently a barrier to their widespread adoption. We are implementing a new technological approach that paves the way for large-scale use of QCLs for non-invasive monitoring of glucose and other physiological parameters. »

Vincent Destefanis, Partnerships manager, Optics and photonics division, CEA-Leti

Transcutaneous glucose measurement device ↓

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In vitro diagnostics

Toward a miniaturized hematology analyzer

After 10 years of successful co-development, CEA-Leti is now supporting Horiba in the industrialization of a hematology analyzer. The commercialization of this more compact and equally precise device, which is cheaper to purchase and use than current models, is planned for 2027.

→ How does it work?

The analysis is conducted using a very small sample, equivalent to a drop of blood. The biological fluid is guided through the channels of a plastic microfluidic card for the reactive operations of sample preparation. Dilution is performed using a micro-pump consisting of a hyper-elastic membrane integrated into a thermoplastic microfluidic card. Then, an ultra-compact lensless imaging device does the counting. The fully automated system can be used by a lab technician after a short training period.

→ What are the advantages?

Thanks to microfluidics and lensless imaging, the analyzer is much less bulky than current laboratory devices: its size is roughly that of a shoebox. It performs rapid, precise, low-cost, and operator-independent measurements.

The FlowStretch hyper-elastic membrane technology ensures on-chip dilution operations with the required rate for reliable counting of red and white blood cells and platelets in a blood sample. Additionally, CEA-Leti has established an industrialization process for microfluidic cards, including those integrating FlowStretch, with the plastics manufacturer Infiplast*. The goal is to transition from an R&D process using machining to small and medium-scale production through plastic injection, compatible with the expected volumes in the healthcare microfluidics market.

This technology is protected by 4 patents involving CEA-Leti.

→ Our research axes:

- Ultra-compact lensless imaging.
- Hyper-elastic membrane (elongation: 300%) for blood dilution.
- Industrialization of the microfluidic card for transfer.

→ What applications?

- Blood cell count: red blood cells, white blood cells, and platelets.

**This industrialization benefits from the support of the FRAMES sector, funded by the France2030 program in the Auvergne-Rhône-Alpes region, and led by the plastics manufacturer Infiplast with expert support from CEA-Leti. FRAMES (Regional sector in Auvergne-Rhône-Alpes for microfluidics in healthcare) de-risks and accelerates the industrialization of thermoplastic microfluidic consumables.*

↑

The analyzer ensures blood dilution via a microfluidic card equipped with a hyper-elastic film, as well as the detection and counting of blood cells through lensless imaging.

«

The combination of two key CEA-Leti technologies, lensless imaging and FlowStretch microfluidic technology, addresses the challenges of the point-of-care market with a high degree of maturity. »

Yann De Boysson, Partnerships manager, Health division, CEA-Leti

→ **In partnership with:** HORIBA

Tools for pharmaceuticals and biotechnologies

Better development, production, and administration of (bio)medicines

A technological transformation of the pharmaceutical industry is underway

Optimizing the often long, complex, and costly stages of pharmaceutical development is a key challenge. The use of organs and organoids-on-chips is a promising avenue in which CEA-Leti is particularly active. These novel biological tools help understand the mechanisms of action of active ingredients, improve the reliability of (pre)clinical trials, and select the most suitable therapeutic molecule for each patient.

Low (bio)production yields are also a problem on the verge of being solved thanks to disruptive technologies such as artificial intelligence, real-time online monitoring of critical parameters, and optimization of analytical platforms. Through its tools, its involvement in the national acceleration strategy implemented in this field, its participation in the PIIEC Santé, and its membership in France Biolead (www.france-biolead.fr), CEA-Leti is working toward a goal shared by the state and pharmaceutical industry: drastically optimizing the yield of certain (bio)production process steps to enhance the attractiveness and industrial sovereignty of France and Europe in this sector.

Finally, drug administration methods are evolving with technologies such as Lipidots®, which help optimize the delivery of vaccines and mRNA therapies, as well as microneedle patches applied to the skin for alternative vaccine delivery or the treatment of skin cancers.

Organs and organoids-on-chips

Validating drug candidates with greater reliability and at lower cost

Today, developing a drug candidate takes about 10 years, costs up to 1 billion euros, and ends in failure in 90% of cases. With instrumented organoids-on-chips, it would be possible to have more representative, more reliable, and less costly models while reducing animal testing.

→ How does it work?

Cells derived from human tissues or stem cells are "cultured" in a microfluidic chip that ensures optimized perfusion of the nutrients necessary for their survival and dynamically supports their growth and maturation through shear forces. The resulting 3D microstructure more faithfully reproduces the structure and functions of the original living tissue.

→ What are the advantages?

World-leading results published in 2024 by CEA show that an organoid can be sustainably maintained in culture on a microfluidic chip, vascularized, and made more representative of the original living tissue compared to traditional cell cultures. Organoids-on-chips are also more predictive of the toxicity and efficacy of drug candidates than animal models, in line with recent regulatory developments. CEA-Leti's microfluidic chips, designed according to new ISO standards with industrializable materials and processes, optimize flows, provide perfusion and trapping functions, while preparing for the future integration of miniaturized sensors. The goal is to enable functional maturation and optimized monitoring of biological objects on chips.

→ Our research axes:

- Microfluidic integration of organoids-on-chips and sensors to monitor the environment and functionality.
- Manufacturing of industrializable microfluidic components.
- Growth, vascularization, and immune competence of organoids on microfluidic components.
- Functionality studies of organoids-on-chips using dedicated miniaturized sensors.
- Monitoring through imaging and associated interpretation algorithms.

→ What applications?

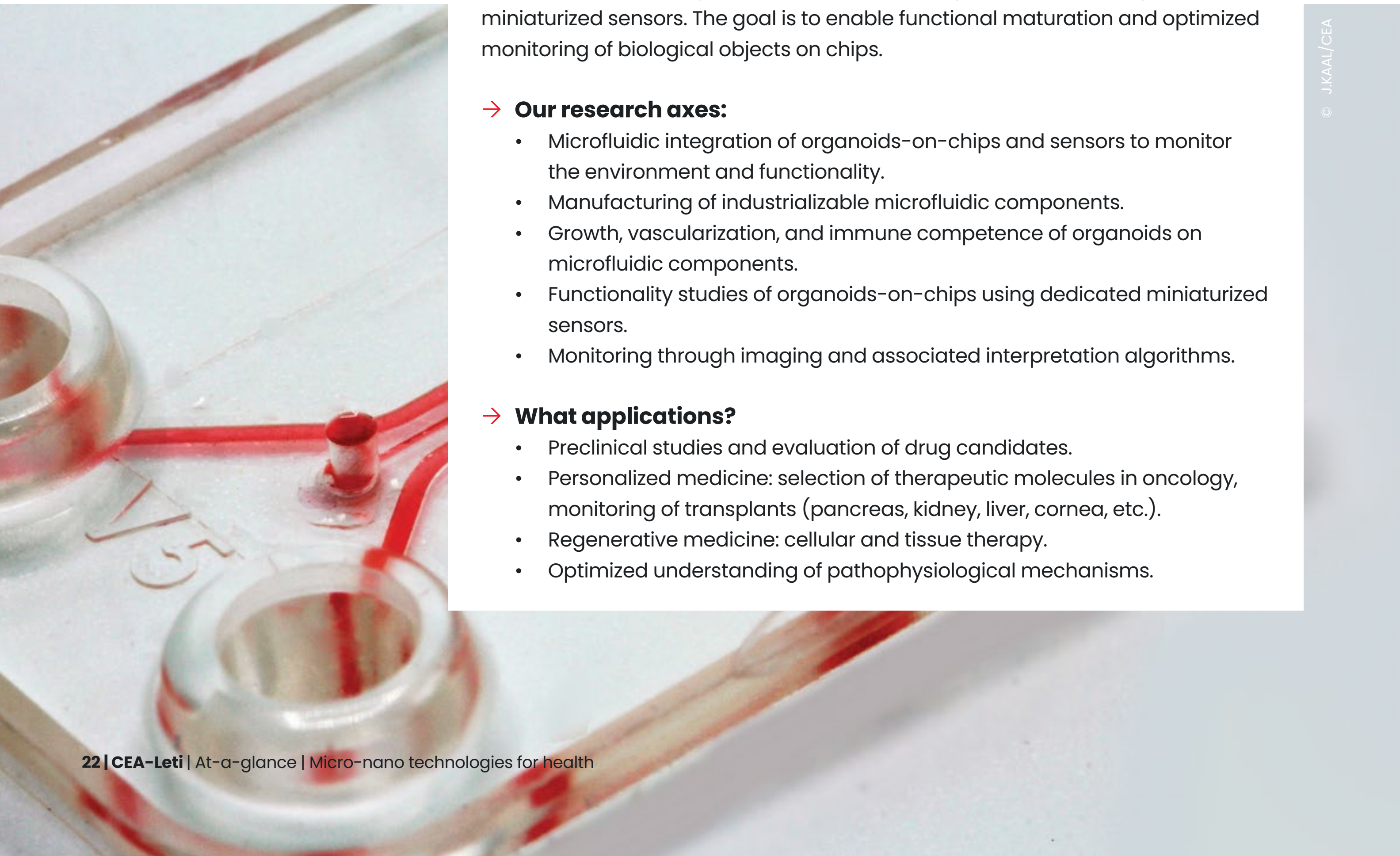
- Preclinical studies and evaluation of drug candidates.
- Personalized medicine: selection of therapeutic molecules in oncology, monitoring of transplants (pancreas, kidney, liver, cornea, etc.).
- Regenerative medicine: cellular and tissue therapy.
- Optimized understanding of pathophysiological mechanisms.

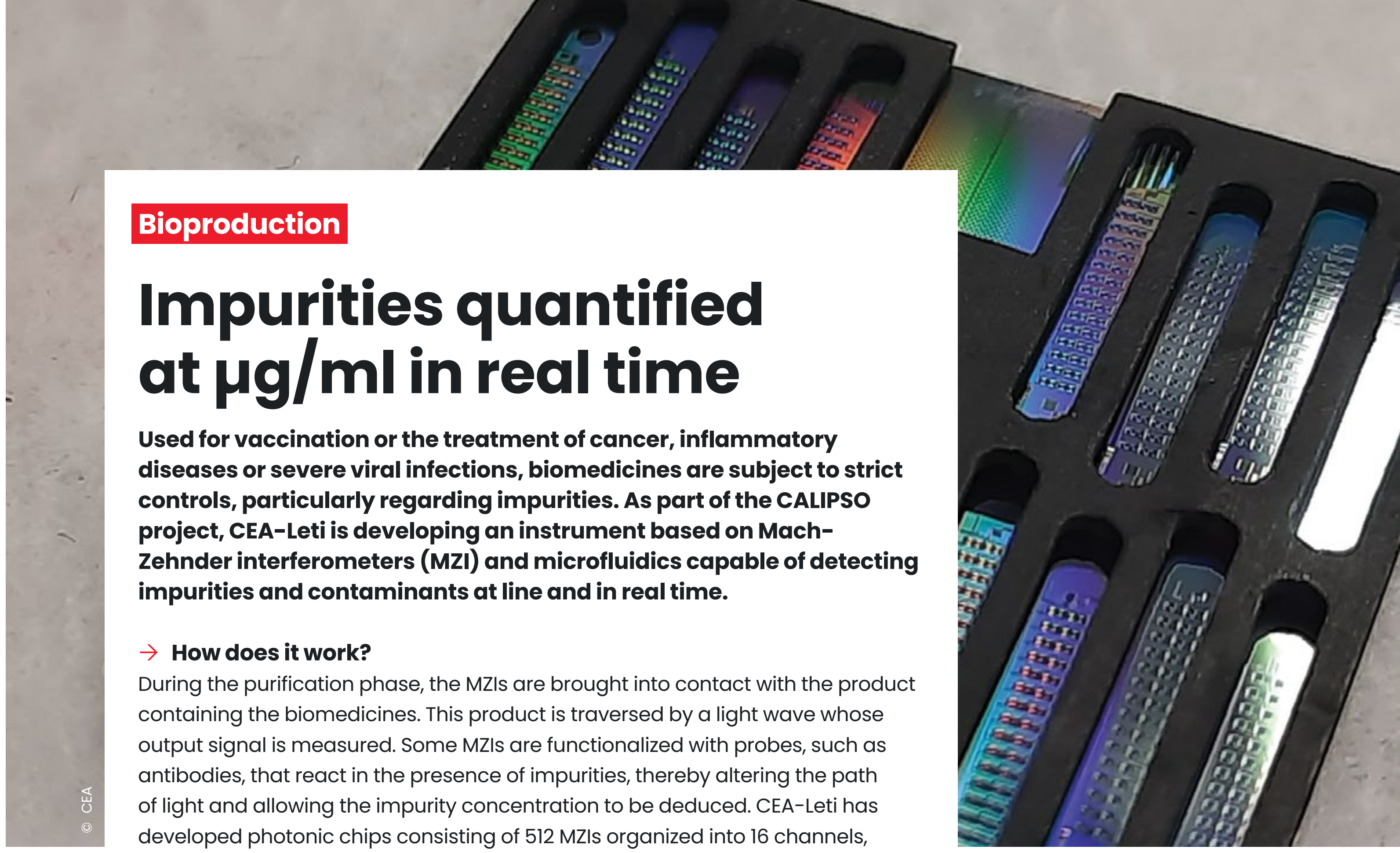
→ See also:

Integrated pneumatic micro-pump for automated glucose-stimulated insulin secretion in single-islet microfluidic platform. Hut, M., Clément, F., Tubbs, E., Caullet, P., Armanet, M., Domet, T., Bouzakri, K., Bietiger, W., Navarro, F., Fouillet, Y., Agache, V. (2026) Biofabrication, Vol. 18. doi.org/10.1088/1758-5090/ae2a72.

Automated microfluidic platform for single spheroid culture and extracellular vesicle isolation: application to spheroid transcriptomic profiling. Hut, M., Denis, J., Bottausci, F., and al. (2025) Small 21, no. 48 https://doi.org/10.1002/smll.202508115.

→ In partnership with:





Bioproduction

Impurities quantified at µg/ml in real time

Used for vaccination or the treatment of cancer, inflammatory diseases or severe viral infections, biomedicines are subject to strict controls, particularly regarding impurities. As part of the CALIPSO project, CEA-Leti is developing an instrument based on Mach-Zehnder interferometers (MZI) and microfluidics capable of detecting impurities and contaminants at line and in real time.

→ How does it work?

During the purification phase, the MZIs are brought into contact with the product containing the biomedicines. This product is traversed by a light wave whose output signal is measured. Some MZIs are functionalized with probes, such as antibodies, that react in the presence of impurities, thereby altering the path of light and allowing the impurity concentration to be deduced. CEA-Leti has developed photonic chips consisting of 512 MZIs organized into 16 channels, assembled in a microfluidic card that can be inserted into a rapid analysis system. Such a system enables phase shift detection as well as fluidic control for automatic sample injection. The response time is on the order of one minute. Each chip can perform 16 measurements.

→ What are the advantages?

Impurity detection occurs directly and in near real time during the bioproduction purification phase. It can complement a PAT (Process Analytical Technology) approach in addition to the controls performed at the end of the process. Anomalies are thus detected quickly, and corrective actions can be implemented to optimize yields and production costs. The sensitivity, on the order of µg/ml, and the sampling rate and result delivery are particularly suited for on-site field control use.

This technology is protected by more than ten patents.

→ Our research axes:

- Optimization of processing times and measurement sensitivity.
- Pre-industrialization of the microfluidic card.
- Technological maturity improvement of the instrument.
- Development of a second instrument for sampling and transporting samples from bioproduction equipment (from *at line* to *in line* control).
- Deployment of measurements for new target/probe pairs.

→ What applications?

- Bioproduction: continuous detection of impurities at very low concentrations.
- Agri-food: detection of allergens (e.g., gluten) and contaminants.
- Medical diagnostics.
- Water analysis.

→ See also:

A silicon photonics platform based on Mach Zehnder interferometers for real-time bioprocess monitoring. Laplatine, L., et al. (2024). Proceedings SPIE 2024. doi.org/10.1117/12.3001513.

SUCCESS STORY: CALIPSO PROJECT

Since 2021, CEA has been participating in the French collaborative research project Calipso with five partners: Sanofi, Gapgemini, Ypso-Facto, GPC Bio, and Centrale Supélec. The goal: to develop a new generation of tools to revolutionize methods for developing and controlling industrial bioproduction processes. This project led to the creation of the start-up Calipso Sensor, a subsidiary of GPC Bio, which will handle the industrialization and commercialization of the sensors developed in the project.

→ With the support of:

Drug Delivery

Lipidots®, a vector for administering vaccines and RNA therapies

Lipidots® are biocompatible oil-in-water nanodroplets capable of transporting active ingredients, contrast agents, or adjuvants to a target organ. They open up promising prospects for RNA vaccines and therapies in terms of stability and efficacy.

«

Lipidots® open up unprecedented perspectives in terms of cost, efficacy, and ease of storage for mRNA vaccines. We are working with several academic and industrial partners, from start-ups to major pharmaceutical groups. »

Marie-Line Cosnier, Engineer and project manager, CEA-Leti

→ How does it work?

Lipidots® measure between 50 and 120 nanometers in diameter. They can vectorize messenger RNA (mRNA) grafted onto their external surface in a stable manner and have a strong affinity with lymph nodes, which are highly involved in the immune response.

→ What are the advantages?

Lipid nanoparticles, in which mRNA is encapsulated during manufacturing, require a cold chain at -80°C. In contrast, with Lipidots®, the mRNA grafting on the surface is performed just before use. They can therefore be stored for at least two years at +4°C and are easier to produce and store. They also exhibit lower toxicity than many competing solutions. Capable of targeting a specific organ or area of the body, they achieve the same therapeutic efficacy with a lower amount of active ingredient, thus reducing costs and limiting side effects.

Work conducted since 2022 had established the in vitro proof of concept in mice for the delivery of large-size mRNA by Lipidots®. Since then, two vaccination campaigns on other animal models have been carried out, notably in collaboration with CEVA Animal Health as part of a France 2030 project, revealing antibody secretion beyond the required threshold and protection as effective as the reference solution. An ethanol-free industrial manufacturing process has been developed and transferred. It enables large-scale production with increased safety and reduced environmental impact.

This technology is protected by 15 patents.

→ Our research axes:

- Scaling up the ethanol-free manufacturing process.
- Adding an immunostimulant for compliance with regulatory constraints (antibody secretion upon injection).
- Expanding to new targets and species.

→ What applications?

- RNA-based vaccines and therapies.
- Tools for new biotherapies (gene and/or cell therapy).
- Release of adjuvants, in addition to vaccines and immunotherapies.

→ See also:

Nanostructured Lipid Carriers Overcome the Low Immunogenicity of M2e Peptide via Surface Click Chemistry Conjugation, Improving the Anti-M2e Antibody Response. Bourlon, L., Fournier, C., Hoang, A., et al. (2026). Advanced Nanobiomed Research. doi.org/10.1002/anbr.202500236

→ With the support of:

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Instrumented microneedles

Microneedles: from biological parameter monitoring to therapy

Painless and minimally invasive, the microneedles developed at CEA-Leti have multiple uses. Their combination with precision microfluidics, biosensors, or next-generation optical sensors enables continuous monitoring of biological markers and photodynamic therapy for skin cancers (clinical trial in 2026).

→ How does it work?

Less invasive than a conventional needle, CEA-Leti's biocompatible polymer microneedles reach the dermis without causing pain, serving various purposes: collecting interstitial fluid, delivering active ingredients or light, measuring physiological characteristics, or dosing biomarkers. These microneedles are integrated into a complete system including microfluidic, optical, or electrochemical components, as demonstrated by CEA-Leti in 2025 as part of a project developing on an innovative approach for treating skin cancers. The complete device is in the form of a patch directly applicable to the skin.

→ What are the advantages?

Full and miniaturized integration of microneedles with cutting-edge instrumentation ensures adapted perforation for each part of the body and in situ, minimally invasive, and high-performance measurement. The optical properties allow control of light propagation in tissues, and when coupled with an active ingredient whose release rate can be controlled, they make photodynamic therapy more effective and less painful. The integration of in situ sensors allows measurement and monitoring of biomarker evolution in interstitial fluid.

CEA-Leti's microneedles are protected by more than 10 patents.

→ Our research axes:

- Microneedle patches.
- High-volume manufacturing with industrial partners in compliance with regulatory requirements.

→ What applications?

- Photodynamic therapy treatment.
- Transdermal delivery of active ingredients from a few minutes to several days.
- Diagnosis and personalized medicine.

→ Key figures:

- A wide range of microneedle sizes and geometries, from 400 µm to 1,400 µm in height, from 300 µm to 400 µm in diameter, solid or hollow, conical or cylindrical, with 1 or more beveled tips to control epidermal perforation.
- A variety of patch formats: round or square, from 1 cm² to 6 cm², with a density varying from 4 to 140 microneedles per patch.

→ See also:

Biodegradable microneedle-based electrodes for electrophysiological measurements. Juillard, S., Planat-Chrétien, E., Texier, I., (2025). Journal of Materials Chemistry B, 13, 10009-10019. DOI: 10.1039/d5tb00727e.

Prevention and well-being

Technological tools for **enhanced prevention**

Prevention is gaining momentum, particularly in the health policies of states.

Prevention covers all determinants of maintaining good health throughout life: individual behaviors, diet, physical activity, health safety, awareness of everyday risks, environmental control (water, air, soil, etc.), animal health, and more.

In practice, these prevention policies rely on advanced tools, services, and technologies. These are used in particular to continuously measure relevant parameters, transmit alerts, and inform decision-making by field actors.

To address these needs, CEA-Leti develops wearable solutions that deliver rapid results as precise and robust as laboratory reference technologies, at a low cost, facilitating large-scale deployment.

Application examples: detection of respiratory viruses in the air, whether dangerous to humans or livestock; bacteriological control of seawater for oyster farming; high-sensitivity and high-specificity detection of falls, as part of home care for the elderly.

SUCCESS STORY: NAWU

Created in 2025, the company nawu diagnostics will leverage CEA's AirCheck technology based on CEA patents. It will initially target the livestock sector, with commercial products available by the end of 2027 for cattle. nawu diagnostics will then extend its offering to the poultry and pork sectors, and aims to expand its activities to human health.

The CATMOS project (Continuous surveillance beacon for airborne biological threats), led by CEA, is a winner of the 2025 call for projects under the Priority Research Program and Equipment on Emerging Infectious Diseases (PEPR MIE), funded as part of the France 2030 plan and managed by INSERM through ANRS MIE. In collaboration with Université Lyon 1, Université de Bordeaux, and Institut Pasteur in Paris, this project aims to develop a disruptive technology to monitor the presence of pathogens in the air.

→ **With the support of:**

Rapid detection of airborne pathogens

30 minutes to detect pathogens in the air

Faced with the risks of emerging and re-emerging respiratory infections spreading via droplets or aerosols, CEA-Leti has developed a unique system: AirCheck, capable of monitoring the "quality" of air in confined environments. As an all-in-one solution, it performs automatic aerosol sampling, sample preparation, and analysis in just 30 minutes.

→ How does it work?

The miniaturized and portable system automatically performs simultaneous detection of more than a dozen pathogens for a variety of applications (hospital air tracking, livestock farming, public space air surveillance, etc.). Three steps are completed in 30 minutes: collection of (bio) aerosols from ambient air by electrostatic precipitation, sample preparation on an embedded microfluidic card and biomolecular detection by isothermal amplification (LAMP).

→ What are the advantages?

All existing reliable and robust solutions require manual steps to prepare the collected sample and transfer it to an analysis module. Performing the analysis in situ and in half an hour provides record responsiveness for early and preventive decision-making. A proof of concept was carried out in the laboratory on a human respiratory virus (Covid-19) in collaboration with the Institut Pasteur (ANR Flash Covid-19 funding), followed by test campaigns in experimental farms and cattle breeding facilities in collaboration with INRAE (UMR BIOEPAR, INRAE/Oniris, UMR IHAP, INRAE/ENVT) and IDELE (inter-Carnot funding). The device requires no training or laboratory instrumentation skills. The accuracy of the results is comparable to that of a PCR.

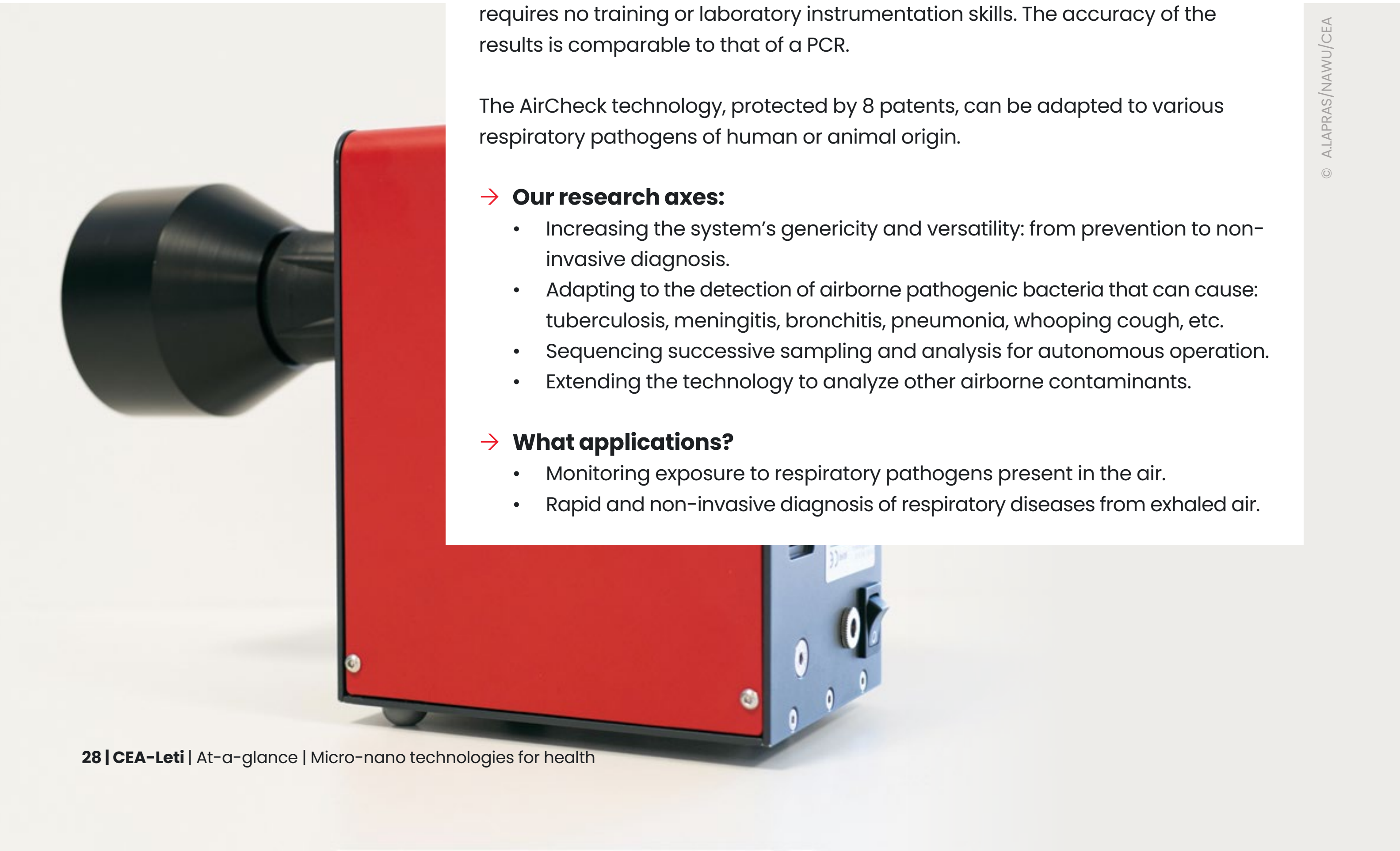
The AirCheck technology, protected by 8 patents, can be adapted to various respiratory pathogens of human or animal origin.

→ Our research axes:

- Increasing the system's genericity and versatility: from prevention to non-invasive diagnosis.
- Adapting to the detection of airborne pathogenic bacteria that can cause: tuberculosis, meningitis, bronchitis, pneumonia, whooping cough, etc.
- Sequencing successive sampling and analysis for autonomous operation.
- Extending the technology to analyze other airborne contaminants.

→ What applications?

- Monitoring exposure to respiratory pathogens present in the air.
- Rapid and non-invasive diagnosis of respiratory diseases from exhaled air.



Biological monitoring

Monitoring the biological quality of seawater in 1 hour

Some professionals, such as oyster farmers, need seawater of good biological quality, for example to rinse oysters exposed to various forms of pollution. With several partners, CEA-Leti is developing an innovative, portable solution for on-site bacterial detection designed to deliver rapid and low-cost results.

→ How does it work?

Starting with a 4-liter seawater sample, an automated measurement system performs a pre-concentration step to obtain a 10 ml volume for analysis, followed by the direct detection of fecal coliforms (such as E. coli) and, in the future, other pathogens, without a genetic amplification step. Detection is ensured by graphene- or silicon-based sensors functionalized with antibodies.

The water sample is collected by a drone carrying the measurement system. Results are transmitted to a secure server. The entire process takes one hour.

→ What are the advantages?

This solution replaces sending the sample to a laboratory and waiting 8 to 16 hours for results. The one-hour delay allows field professionals to optimize their work. For oyster farmers, for example, it means quickly knowing whether they can rinse their oysters without health risks. The system is expected to eventually achieve the required detection sensitivity of 200 to 1000 bacteria/100 ml. It uses off-the-shelf sensors, making controls low-cost. The project aligns with sustainability: reducing environmental impact with minimal energy consumption, and compatibility with sensitive marine ecosystems.

The development of this system has already led to the filing of 3 patents.

→ Our research axes:

- Functionalization of graphene or silicon sensors for bacterial detection.
- Pre-concentration of seawater samples by tangential filtration, coupled with direct sensor detection without genetic amplification.
- Improving detection sensitivity.
- System integration.

→ What applications?

- Oyster farming: monitoring seawater used for rinsing and purifying oysters.
- Monitoring water used to transport fruits and vegetables.
- Algae farming in ponds.
- Monitoring drinking water reserves on ships.

«We are developing a rapid and robust on-site microbiological detection solution to enable water stakeholders to respond to bacterial contamination in less than one hour. »

Thomas Alava,
Project manager at CEA-Leti

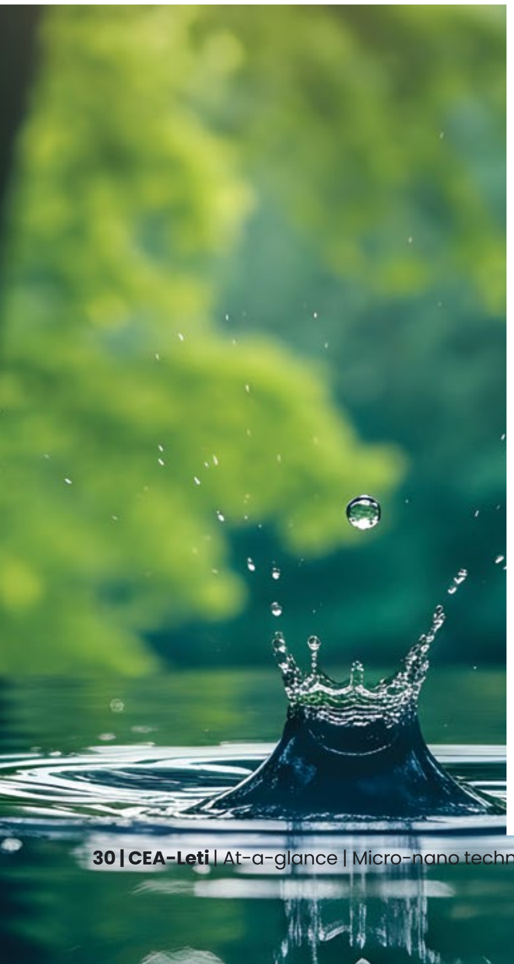
«

The demand for real-time water quality monitoring and associated challenges is growing. With the BioSensei project, CEA-Leti addresses numerous challenges to develop the appropriate technology. The diversity and complementarity of the partners are key assets in meeting this challenge. »

Elise Saoutieff,
Project manager, Health division, CEA-Leti

→ **With the support of:**

European Union's Horizon Europe Framework Programme (HORIZON) under grant agreement 101135241 — BIOSENSEI



Prevention: water quality

Toward real-time monitoring of existing and emerging pollutants

Environmental pollution poses a major threat to health and biodiversity. As part of the European BioSensei project, CEA-Leti is developing an innovative, multiplexed, and deployable on-site hybrid biosensor capable of detecting pollutants in real time using genetically modified microorganisms.

→ How does it work?

Launched in January 2024, the European BioSensei project (3 years, 9 partners) is developing an innovative, multiplexed, and deployable on-site hybrid biosensor capable of detecting abiotic pollutants (nutrients, estrogenic endocrine disruptors, and PFAS*) and biotic pollutants (microcystins) in real time using genetically modified microorganisms.

CEA-Leti integrates electrochemical and optical sensors into a complete IoT** system. It handles the electronic architecture, sensor control, and integration into LTE networks (mobile network). In parallel, it is developing a process for encapsulating modified bacteria to prevent any release while preserving their viability and sensor performance.

→ What are the advantages?

In line with the "Safe and Sustainable by Design" ecodesign principles, CEA-Leti is developing chemical surface functionalization processes and biocompatible biomaterial shaping processes. Thanks to its multidisciplinary approach, CEA-Leti designs high-performance cell encapsulation processes compatible with miniaturized and industrializable systems while ensuring the viability and analytical performance of the devices. It masters the integration of complete systems, including the control of hybrid optical and electrochemical sensors and the development of IoT nodes with wireless NB-IoT communication.

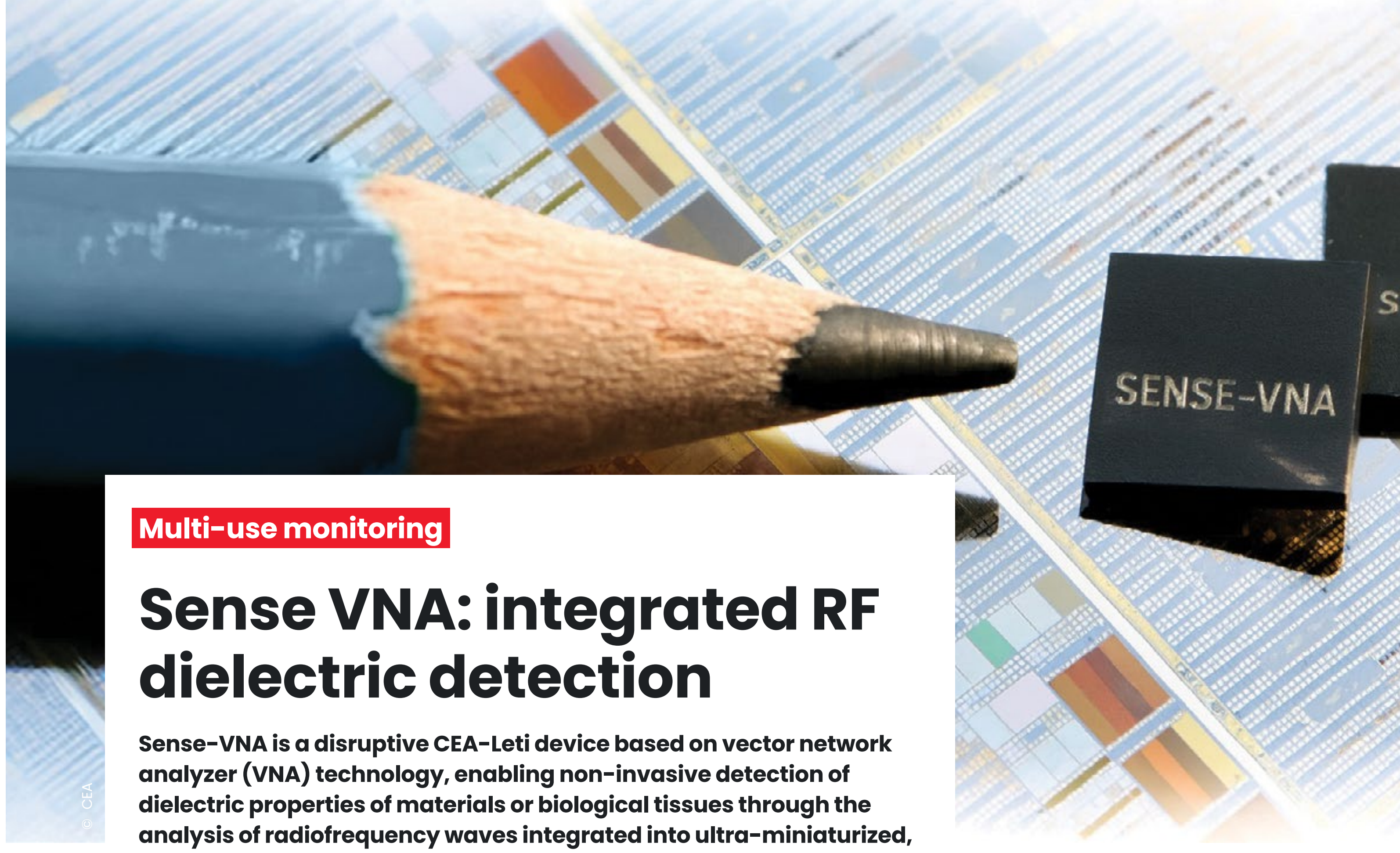
→ Our research axes:

- Biocompatible, non-toxic, and cost-effective encapsulation.
- Low-power electronics.
- Integration of new electrochemical and optical sensors.

→ What applications?

- Prevention of environmental risks and quality of soils and environmental waters: industrial effluents, agri-food operations.
- Real-time monitoring and alerts.
- Chemical bioproduction.

**PFAS: perfluoroalkyl and polyfluoroalkyl substances*
***IoT: Internet of Things (in French, "Internet des objets"). This term refers to the set of connected physical objects that have their own digital identity and can communicate with each other.*



Multi-use monitoring

Sense VNA: integrated RF dielectric detection

Sense-VNA is a disruptive CEA-Leti device based on vector network analyzer (VNA) technology, enabling non-invasive detection of dielectric properties of materials or biological tissues through the analysis of radiofrequency waves integrated into ultra-miniaturized, low-cost, and low-power analyzers.

→ How does it work?

Sense VNA leverages the dielectric permittivity of materials, a property that describes how an electric field propagates through matter. Radiofrequency waves are used to measure incident, transmitted, and reflected signals. These signals are then decoded using a silicon-based miniaturized VNA to extract dielectric parameters and map the otherwise invisible signatures of cells or materials.

→ What are the advantages?

Compared to conventional Vector Network Analyzers, Sense VNA provides an approach tailored to embedded systems. Ultra-miniaturized, energy-efficient, and low in unit cost, this technology paves the way for a wide range of opportunities in non-invasive detection and monitoring, enabling remote or even portable applications.

→ Our research axes:

- Validation of identified use cases using an initial non-integrated platform.
- Development of a more highly integrated version based on advanced silicon technology.
- Co-development including the antenna component to optimize performance and miniaturization.

→ What applications?

- Measurement of skin hydration; product efficacy testing for cosmetic R&D.
- Well-being: dehydration monitoring integrated into a smartwatch.
- Process control: monitoring of fermentation processes.
- Proximity detection in the near field of an antenna (20 cm to 1 m).
- Medical: differentiation between healthy and pathological tissues (oncology, probe-integrated analysis, biopsy tissue analysis), biomarker identification, and monitoring of physiological parameters.

→ See also:

Direct Magnitude and Phase Measurement in an Inductorless Integrated Vector Network Analyzer for Wideband Ambient Environment Sensing. Yaakoubi, G., et al. (2024). Proc. IEEE NEWCAS Conference (NEWCAS), pp. 420-424. 2025. doi: 10.1109/NewCAS64648.2025.11107094

EM-Wave Biosensors: A Review of RF, Microwave, mm-Wave and Optical Sensing. Mehrotra, P., et al. (2019). Sensors, Feb. 2019. doi.org/10.3390/s19051013

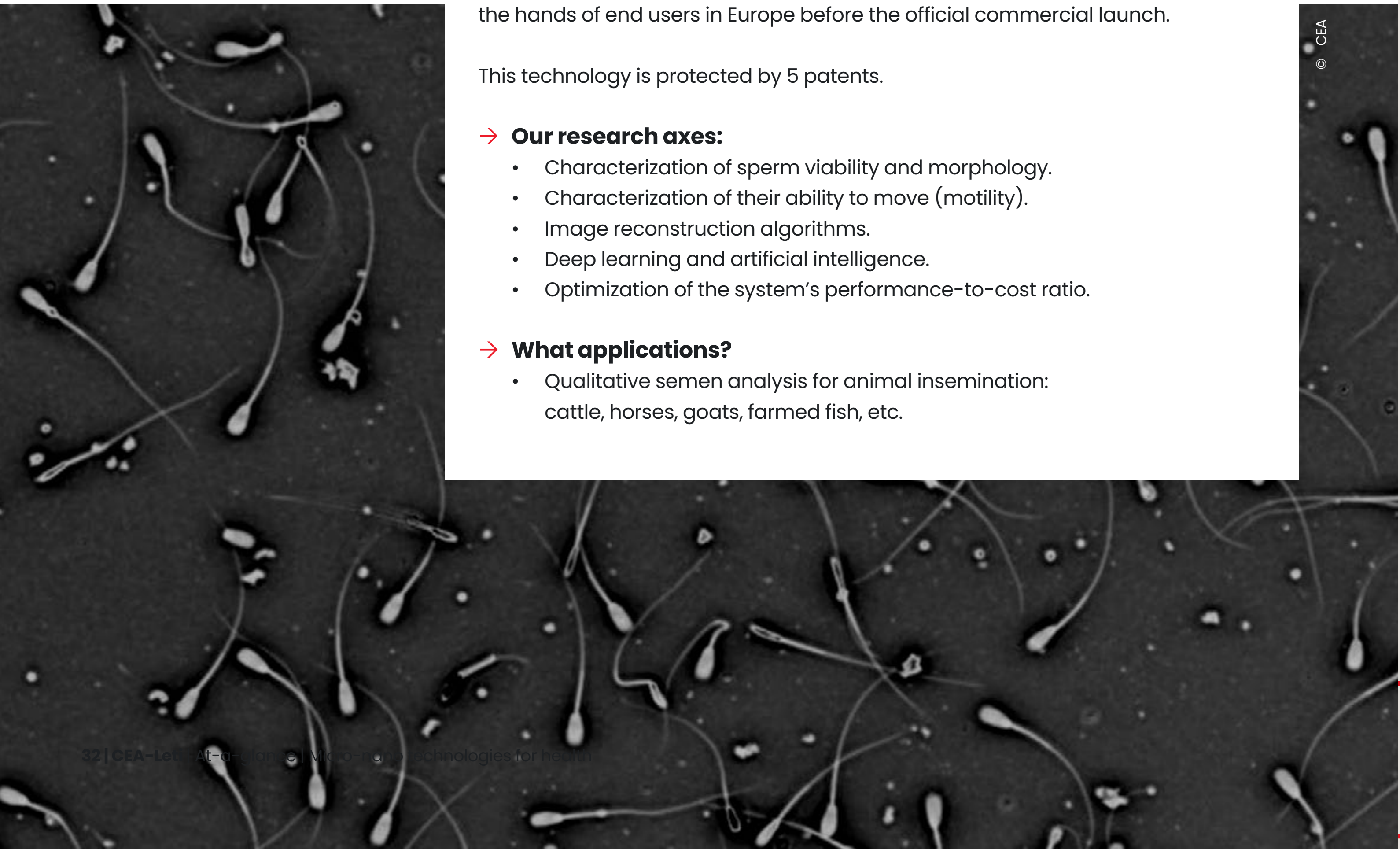
«

Holographic imaging enables the development of miniaturized, automated, and easy-to-use solutions, with algorithms leveraging the potential of artificial intelligence. A significant added value for animal insemination. »

Caroline Paulus, Head of the Optical instrumentation and information processing laboratory for in vitro imaging, CEA-Leti

→ **See also:**
Phase and fluorescence imaging with a surprisingly simple microscope based on chromatic aberration. Mandula, O., et al. (2020) Opt. Express. doi: 10.1364/OE.28.002079.

Microscopic observation of bovine sperm
↓



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Artificial animal insemination

An advanced prototype for animal semen analysis

In animal insemination, ensuring the quality of analyses and optimizing the number of doses produced are priorities. CEA-Leti supports a leading industry player in this field with a miniaturized, robust, and cost-effective holographic imaging technology for semen quality analysis. This technology will soon be adapted to a range of automated field analysis instruments.

→ How does it work?

With holographic imaging, mechanical focusing is no longer required. The image is focused and reconstructed through mathematical processing and analyzed using artificial intelligence algorithms. The device can be used without extensive training, either in an industrial environment or on-site near breeding facilities.

→ What are the advantages?

A holographic imager costs ten times less than a conventional microscope and has a much wider field of view, enabling the imaging of thousands of biological objects at once. Its analytical capability relies on its algorithms rather than hardware. Applied to animal insemination, CEA-Leti's technology provides access to semen concentration as well as anomalies, such as slow sperm movement. It integrates into a very compact, easy-to-install device.

Following an extensive development program, a range of equipment is entering the industrialization phase with an industrial partner to cover various uses at different price points. Starting in 2026, a functional pre-series will be placed in the hands of end users in Europe before the official commercial launch.

This technology is protected by 5 patents.

→ Our research axes:

- Characterization of sperm viability and morphology.
- Characterization of their ability to move (motility).
- Image reconstruction algorithms.
- Deep learning and artificial intelligence.
- Optimization of the system's performance-to-cost ratio.

→ What applications?

- Qualitative semen analysis for animal insemination: cattle, horses, goats, farmed fish, etc.

Appendices

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APPENDIX

CEA-Leti technology platforms

Cleanroom platform

Equipped with a world-class suite of microelectronics equipment, the Cleanroom platform develops ultra-miniaturized devices for healthcare applications that combine outstanding performance with low power consumption.

Key figures

- 14,000 m^2 of facilities
- 600 research engineers
- 350+ patents

→ When should silicon be used?
Developing silicon-based components requires significant upfront investment due to the high R&D costs associated with microelectronics. To offset this, production must either reach millions of units or target very high value-added devices. This is why CEA-Leti's Health experts assess the relevance of silicon integration from the earliest design stages. The most common applications include advanced sensors, reusable components for microfluidic circuits, and sensors for bioproduction.

→ Exceptional capabilities
Silicon technologies deliver exceptional performance. For example, they enable the development of micro-resonators capable of detecting masses as small as one ten-thousandth of a billionth of a gram (10^{-14}), making it possible to compare the efficacy of different anticancer drugs within just a few hours. They are also being used to develop process-monitoring sensors for bioproduction, which are expected to significantly increase yields at certain stages of drug manufacturing while improving reliability.

→ Designing manufacturable solutions
The platform features a range of pre-industrial equipment closely aligned with those used by foundries in production environments. For each healthcare development, a complete manufacturing process is validated and then transferred to the final subcontractor. This ensures that industrial partners can rapidly scale up production volumes while maintaining high quality standards and controlled costs (lab-to-market model).

→ Key equipment:
- 200 mm and 300 mm CMOS lines
- 200 mm and 300 mm MEMS lines
- 200 mm and 300 mm MEMS-CMOS co-integration lines
- 100 mm photonics platform
- Nano-characterization platform

Micro and nanotechnologies platform for health

Backed by a team of 150 researchers and equipped with state-of-the-art facilities, CEA-Leti's Micro- and Nanotechnologies for Healthcare platform is used to design and manufacture microfluidic systems, optical systems, and wearable medical devices. It also supports the development of algorithms tailored to healthcare applications.

→ Compliance by design
The objective is to transfer sensors, systems, and algorithms to industrial partners so they can be certified and brought to market as quickly as possible. Regulatory requirements are integrated at every stage of development, ensuring that technologies are compliant by design with the standards governing human health related devices.

→ Microfluidic technologies
Microfluidics is a major source of innovation in healthcare, enabling both point-of-care diagnostics and research on organoids-on-chip systems. With more than twenty years of R&D experience and 46 patent families in this field, the platform team develops solutions tailored to each application, based on a generic microfluidic technology that can incorporate specific microelectronic components. Semi-industrial-grade chips are manufactured in cleanrooms with cleanliness levels adapted to medical requirements.

→ Wearable medical devices
The wearable medical devices designed and integrated on the platform rely on pre-certified technologies for clinical investigation, helping to secure development processes and shorten time-to-market. Given their direct interaction with the human body, they comply with strict safety requirements, including biocompatibility.

→ Lensless imaging
CEA-Leti has strong expertise in lensless imaging. Compared with traditional microscopy, this approach enables rapid imaging over very large fields of view and supports high-throughput image acquisition. It is ideally suited for developing artificial intelligence tools to analyze large-scale imaging datasets.

Key figures

- 1,700 m^2 of cleanrooms and laboratories
- 150 research engineers
- 25 new patents per year
- €15 M in cumulative investments

→ Key equipment:
- Microfabrication: micromachining, laser cutting, hot embossing, sensor and system packaging.
- Surface chemistry: plasma-based surface functionalization.
- Reference medical equipment: EEG, ECG, fNIR, blood pressure, pulse wave, ultrasound, etc.
- Optical benches: Brillouin and Raman spectroscopy, phase microscopy, lensless microscopy.

APPENDIX

Clinatec platform, Edmond J. Safra biomedical research center

Clinatec is a biomedical research infrastructure located at the CEA Grenoble site, bringing together medical research, cutting-edge technologies, and hospital practice. This four-party center is the result of a collaboration between the CEA, Grenoble Alpes University Hospital (CHU Grenoble Alpes), Université Grenoble Alpes, and the Clinatec Fund.

→ A multidisciplinary team

Clinatec's mission is to design, develop, and validate innovative medical devices based on clinical needs and technological advances. Projects are carried out by multidisciplinary teams bringing together physicians, biologists, physicists, electronics engineers, mathematicians, computer scientists, roboticists, and healthcare professionals.

→ An innovation model serving patients

Clinatec accelerates the transition from concept to clinical implementation by promoting a more precise, less invasive, and widely accessible form of medicine. Its teams are particularly engaged in addressing neurodegenerative diseases and disabilities.

Spanning nearly 6,000 m², Clinatec offers a fully integrated hospital environment (six patient rooms, an operating theater, and an imaging platform), along with state-of-the-art technological equipment. This close integration across disciplines enables a streamlined pathway from fundamental research to technological development, preclinical evaluation, and clinical trials.

→ A unique organization for tangible impact

Clinatec is structured around four key areas of expertise, designed to accelerate technology transfer:

- **Design and manufacturing**: development of innovative medical devices up to initial proof-of-concept.
- **Biology**: assessment of biocompatibility and development of diagnostic and therapeutic solutions.
- **Preclinical evaluation**: validation of efficacy and safety in animal models prior to clinical trials.
- **Clinical evaluation**: conduct of clinical studies within a hospital setting, coordinated by CHU Grenoble Alpes.

This integrated organization, combined with direct access to CEA expertise and strong academic and industrial partnerships, makes Clinatec a true accelerator of medical innovation.

cea | CHU Grenoble Alpes | FONDS CLINATEC Make the impossible possible | UGA Université Grenoble Alpes

Key Figures

- 6,000 sq.m of laboratories and hospital setting
- 70 doctors and research engineers
- 65 patents
- €28 M of cumulated investments

APPENDIX

The CEA ecosystem for health technologies

Today, the CEA is a key player in France in the design and integration of innovative technologies for healthcare. This mission is driven by its Fundamental Research and Technological Research divisions.

TECHNOLOGICAL RESEARCH

cea leti

CEA-Leti, a technology research institute at CEA, is a global leader in miniaturization technologies enabling smart, energy-efficient and secure solutions for industry. Founded in 1967, CEA-Leti pioneers micro-& nanotechnologies, tailoring differentiating applicative solutions for global companies, SMEs and startups. CEA-Leti tackles critical challenges in healthcare, energy and digital migration. From sensors to data processing and computing solutions, CEA-Leti's multidisciplinary teams deliver solid expertise, leveraging world-class pre-industrialization facilities. With a staff of more than 2,000 talents, a portfolio of 3,200 patents, 14,000 sq. meters of cleanroom space and a clear IP policy, the institute is based in Grenoble (France) and has offices in San Francisco (United States), Brussels (Belgium), Tokyo (Japan), Seoul (South Korea) and Taipei (Taiwan). CEA-Leti has launched 80 startups and is a member of the Carnot Institutes network.

BASIC RESEARCH

cea irig

The Interdisciplinary Research Institute of Grenoble (IRIG), conducts research in biology, health, nanosciences, cryo-technologies and new technologies for energy and the environment. Physicists, chemists, biologists, physicians, computer scientists and mathematicians participate jointly in this fundamental research and the applications that result from it, giving the institute a remarkable capacity to respond to major societal challenges.

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BASIC RESEARCH

cea jacob

The François Jacob Institute of Biology(CEA-Jacob), located on the CEA-Paris-Saclay sites in Fontenay-aux-Roses, Evry, and Saint Louis Hospital, conducts research in radiobiology and radiotoxicology, neurodegenerative, infectious, and immuno-hematological diseases, and medical and environmental genomics.

BASIC RESEARCH

cea joliot

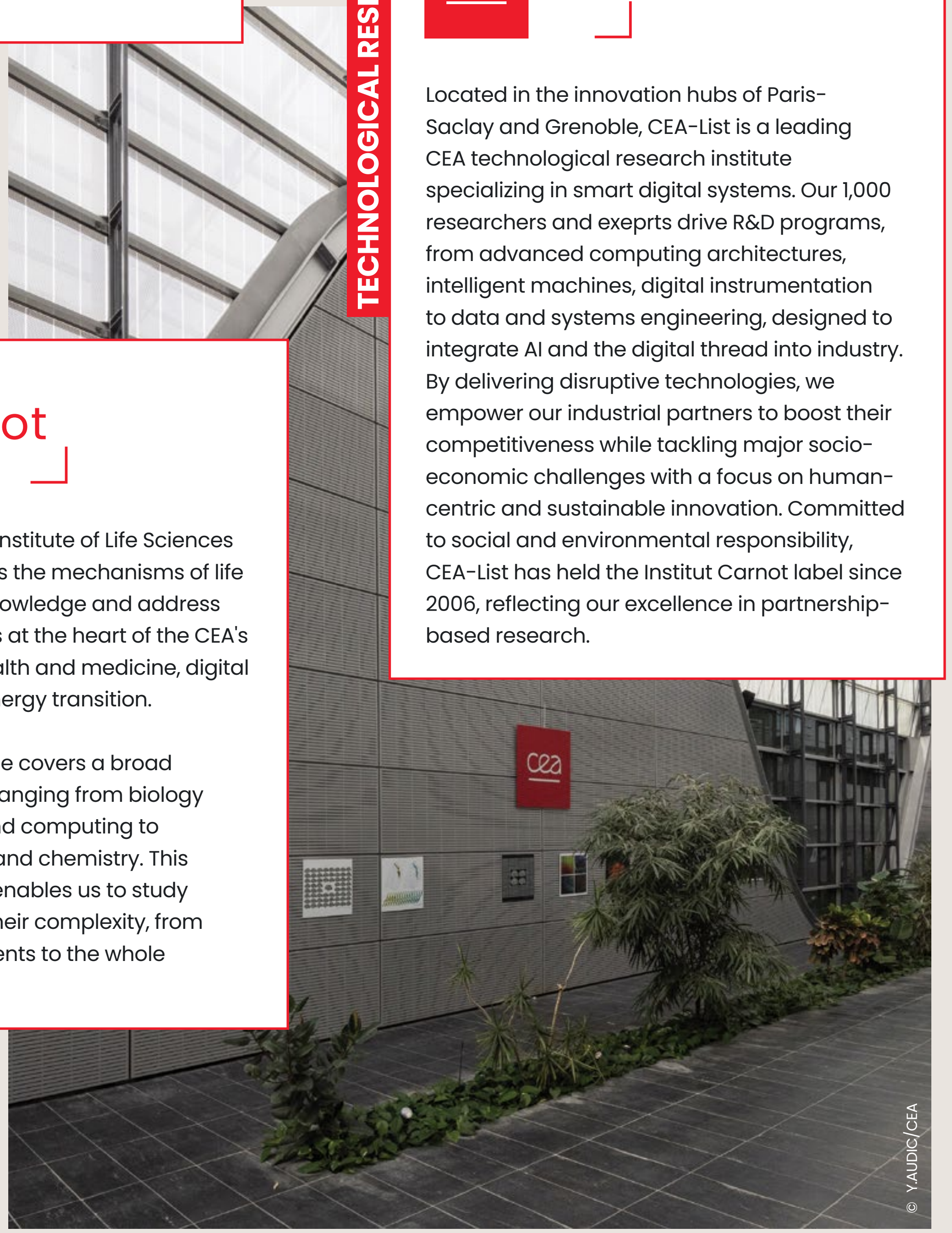
The Frédéric Joliot Institute of Life Sciences (CEA-Joliot) studies the mechanisms of life to both produce knowledge and address societal challenges at the heart of the CEA's strategy: future health and medicine, digital technology, and energy transition.

The Institut expertise covers a broad spectrum of skills, ranging from biology to mathematics and computing to medicine, physics and chemistry. This multidisciplinarity enables us to study living things in all their complexity, from molecular instruments to the whole organism.

TECHNOLOGICAL RESEARCH

cea list

Located in the innovation hubs of Paris-Saclay and Grenoble, CEA-List is a leading CEA technological research institute specializing in smart digital systems. Our 1,000 researchers and exeprts drive R&D programs, from advanced computing architectures, intelligent machines, digital instrumentation to data and systems engineering, designed to integrate AI and the digital thread into industry. By delivering disruptive technologies, we empower our industrial partners to boost their competitiveness while tackling major socio-economic challenges with a focus on human-centric and sustainable innovation. Committed to social and environmental responsibility, CEA-List has held the Institut Carnot label since 2006, reflecting our excellence in partnership-based research.



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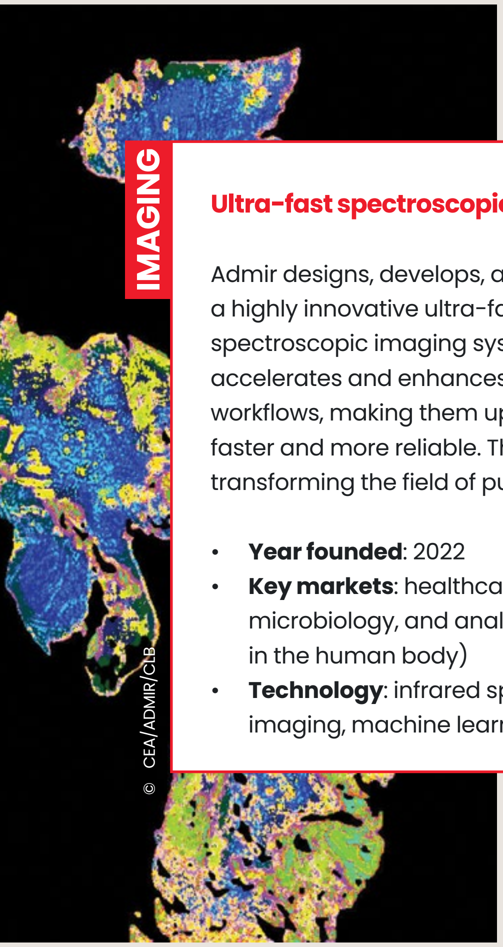
APPENDIX

Supporting startup creation

Selected examples of achievements



ADMIR

IMAGING

Ultra-fast spectroscopic imaging systems

Admir designs, develops, and manufactures a highly innovative ultra-fast infrared spectroscopic imaging system that accelerates and enhances bioanalysis workflows, making them up to 100 times faster and more reliable. This technology is transforming the field of public health

- **Year founded**: 2022
- **Key markets**: healthcare (oncology, microbiology, and analysis of microplastics in the human body)
- **Technology**: infrared spectroscopic imaging, machine learning

WELL-BEING

Relieving chronic pain through endorphin stimulation

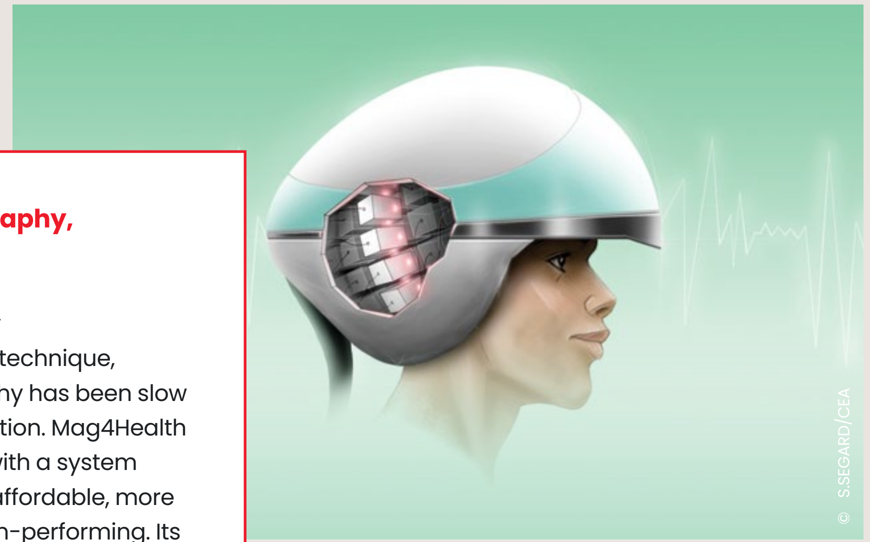
Remedee Labs has developed the first wristband emitting millimeter waves to stimulate the production of endorphins, the body's natural painkillers. The company also offers a digital services platform providing personalized support and a multidisciplinary approach to pain management.

Twelve million people in France suffer from chronic pain, and 70% of them do not receive appropriate treatment.

- **Year founded**: 2016
- **Target indications (clinical studies ongoing)**: fibromyalgia, osteoarthritis, chronic migraine
- **Technology**: 60 GHz millimeter-wave emission via a silicon chip

Remedee Labs

MAG4Health



IMAGING

Magnetoencephalography, finally accessible

A powerful yet historically expensive brain imaging technique, magnetoencephalography has been slow to gain widespread adoption. Mag4Health is democratizing its use with a system that is three times more affordable, more versatile, and equally high-performing. Its MEG devices feature magnetic shielding that is ten times lighter than current systems—around 1 ton instead of 10.

- **Year founded**: 2021
- **Key markets**: epilepsy surgery planning; brain tumor surgery planning; concussion diagnosis; early diagnosis of Alzheimer's disease
- **Technology**: helium-4 quantum sensors operating at room temperature; acquisition system helmet integrating 48 sensors

DIABETES

Self-learning and interoperable solutions for diabetes management

Diabeloop's first solution for the automated treatment of type 1 diabetes continuously calculates the insulin doses required by patients throughout the day and delivers them in an automated and personalized manner. Already deployed in seven European countries, the solution has equipped more than 10,000 people across Europe within one year of its commercial launch through the DBLG1 System.

- **Year founded**: 2015
- **Indication**: treatment of type 1 diabetes
- **Technology**: Dexcom glucose sensor; Diabeloop technology compatible with multiple insulin pumps; artificial intelligence–based algorithm for glycemic control, including hypoglycemia prevention, adaptation to carbohydrate and fat intake, physical activity, and correction boluses in cases of hyperglycemia.

diabeloop

APPENDIX

What CEA-Leti can so for your business

Did you know? Some of our partnerships have been going on for decades. Our satisfied R&D customers keep coming back for the smooth transition from our labs to their factories and for the continued year-on-year results we achieve together.

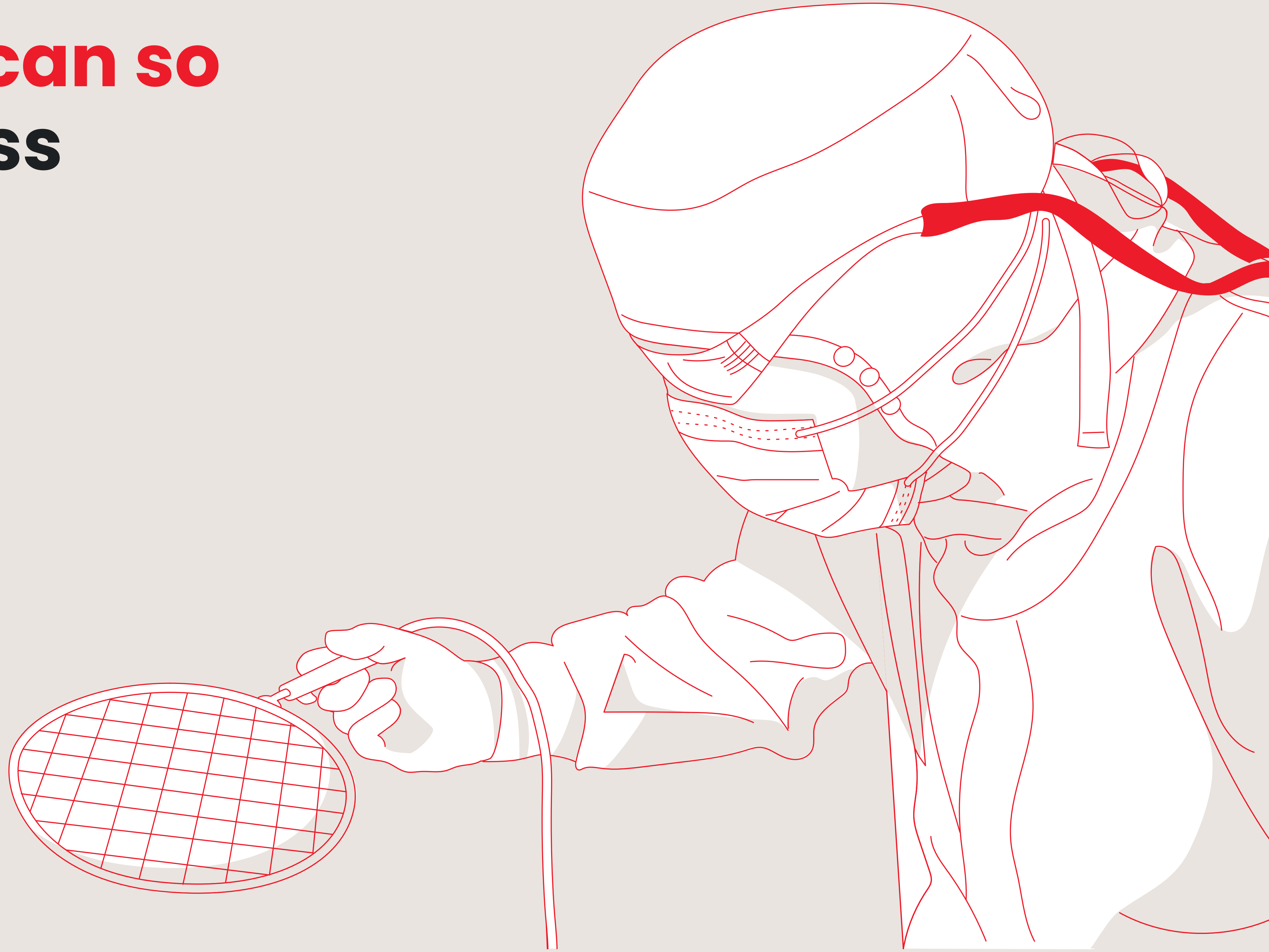
Here's how we can help you take high-value breakthrough concepts from proof-of-concept to volume-manufactured product with lower risk and faster time to market.

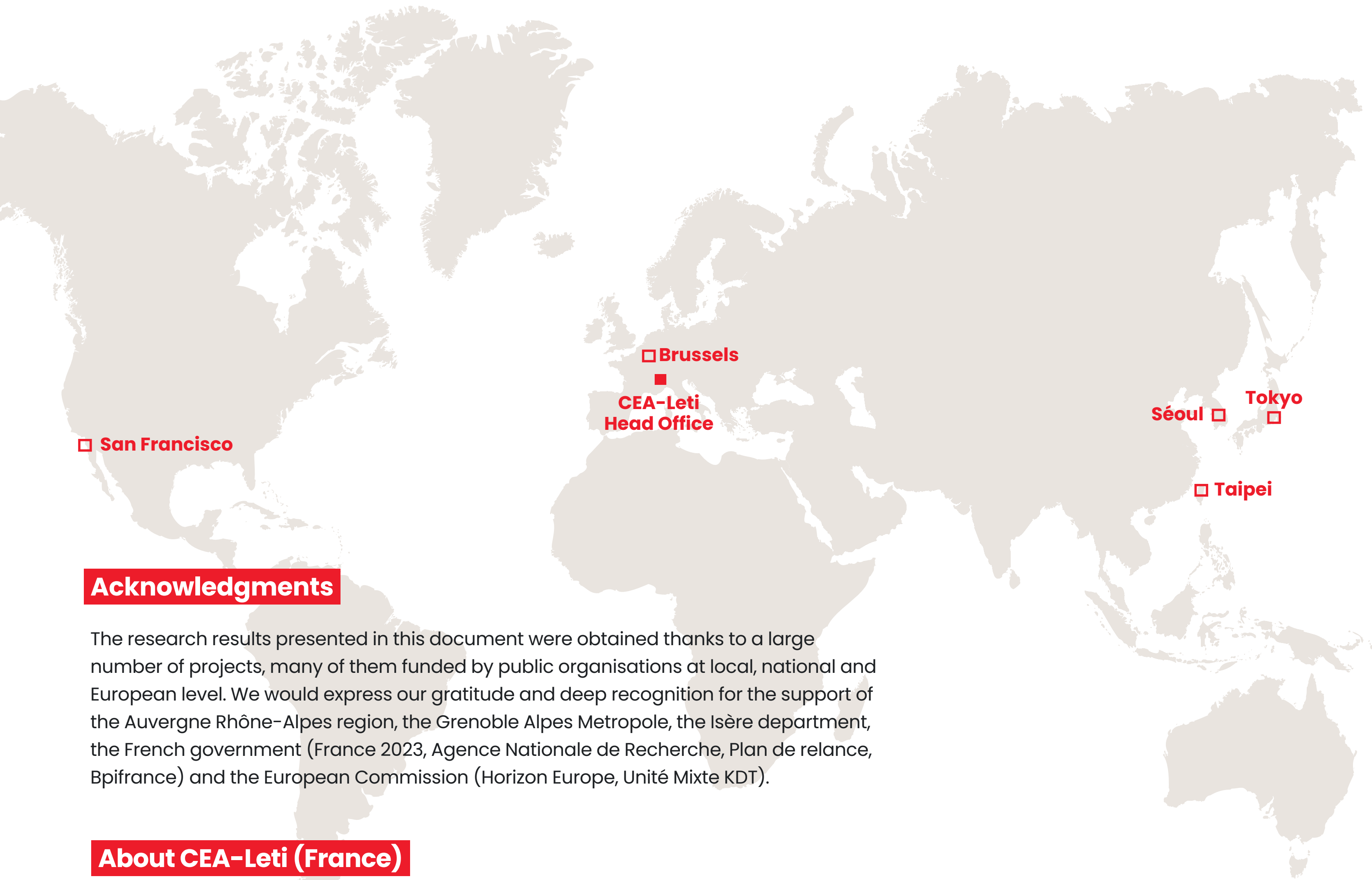
With CEA as your R&D partner, you can count on:

- **World-class R&D facilities** and cleanrooms for testing, prototyping, and test runs on industrial-grade pilot production lines
- The **multidisciplinary expertise** of thousands of scientists and engineers
- An **extensive IP portfolio** and **robust IP policy** that can include exclusive licensing agreements to protect your innovation and competitive advantage
- Strict **confidentiality and robust data protection** throughout the duration of our partnership and beyond.
- Proven experience and processes for **transferring new technologies** to the market for our partners and through CEA startups
- A **rich innovation ecosystem** that spans the entire value chain, from academic research to startups and established companies

World-class R&D facilities

- → Cleanrooms
- → Nanocharacterization
- → Photonics
- → Cybersecurity
- → Micro-Nano Technology for Health
- → Clinatec
- → Telecommunications
- → Cyber-Physical Systems
- → Power Electronics
- → Microsysteme 200 mm & 300 mm
- → Integrated Circuits Design





Acknowledgments

The research results presented in this document were obtained thanks to a large number of projects, many of them funded by public organisations at local, national and European level. We would express our gratitude and deep recognition for the support of the Auvergne Rhône-Alpes region, the Grenoble Alpes Metropole, the Isère department, the French government (France 2023, Agence Nationale de Recherche, Plan de relance, Bpifrance) and the European Commission (Horizon Europe, Unité Mixte KDT).

About CEA-Leti (France)

CEA-Leti, a technology research institute at CEA, is a global leader in miniaturization technologies enabling smart, energy-efficient and secure solutions for industry. Founded in 1967, CEA-Leti pioneers micro-& nanotechnologies, tailoring differentiating applicative solutions for global companies, SMEs and startups. CEA-Leti tackles critical challenges in healthcare, energy and digital migration. From sensors to data processing and computing solutions, CEA-Leti's multidisciplinary teams deliver solid expertise, leveraging world-class pre-industrialization facilities. With a staff of more than 2,000 talents, a portfolio of 3,200 patents, 14,000 sq. meters of cleanroom space and a clear IP policy, the institute is based in Grenoble (France) and has offices in San Francisco (USA), Brussels (Belgium), Tokyo (Japan), Seoul (South Korea), and Taipei (Taiwan). CEA-Leti has launched 80 startups and is a member of the Carnot Institutes network. Follow us on cea-leti.com and @CEA_Leti.

Technological expertise
CEA has a key role in transferring scientific knowledge and innovation from research to industry. This high-level technological research is carried out in particular in electronic and integrated systems, from microscale to nanoscale. It has a wide range of industrial applications in the fields of transport, health, safety and telecommunications, contributing to the creation of high-quality and competitive products.

For more information: cea.fr/english

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Research for industrial innovation