ISSUE 05 | OCTOBER 2026

A FLIM LABS PUBLICATION

LIFETIME

THE FLIM MAGAZINE

Lowering the Barriers to FLIM

Making fluorescence lifetime imaging more accessible to everyone



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“It’s a democratization of cutting-edge research”

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Options, setups, and next steps

LIFETIME
THE FLIM MAGAZINE

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THIS ISSUE

Accessible FLIM: focused instruments, simpler workflows, and lower barriers to fluorescence lifetime imaging.

NOTE FROM FLIM LABS

Why this issue *lowers* the barriers — and opens *access* to FLIM

This October issue of LIFETIME explores how fluorescence lifetime imaging can move from a specialized technique to a more accessible everyday tool for research.

Historically, FLIM has offered a powerful way to read fluorescence beyond brightness. By measuring how long fluorescence lasts, it can reveal information about molecular environment, interactions, metabolism, autofluorescence, and sample conditions that intensity alone may miss.

And yet, despite this potential, FLIM has often remained difficult to access. Historically, lifetime imaging was usually included as one capability inside larger, multipurpose microscopy platforms. These instruments could perform many advanced techniques, but they also came with higher costs, larger setups, and more complex workflows. For researchers who simply wanted to use FLIM, the route was not always direct.

Today, the landscape is changing. Interest in FLIM is growing across research and industry, while lasers, detectors, timing electronics, software, and modular optical platforms are making it possible to rethink what a FLIM system can be.

A focused FLIM approach does not make the science less rigorous. It makes the path to the measurement simpler: lower cost, easier integration, more practical workflows, and instruments designed around lifetime imaging itself.

In this issue, we look at what democratizing FLIM really means — not reducing the value of the technique, but making it available to more laboratories, more researchers, and more scientific questions.

> “Access is not about simplifying the science. It is about simplifying the path to it”



CASE STUDY

FLIM for Everyone

How fluorescence lifetime imaging can move from a specialized technique to a more accessible everyday tool for research.

For a long time, fluorescence lifetime imaging has lived in a strange position. Scientifically, its value has been clear. FLIM can reveal information that intensity-based imaging often misses, because it does not only measure how much light a sample emits, but how long that fluorescence lasts. This lifetime dimension can tell researchers about molecular environment, metabolism, interactions, autofluorescence, and changes inside biological or material samples.

And yet, despite this potential, FLIM has often remained a specialist technique. One reason is historical. The market for FLIM was relatively small, and many companies developing advanced microscopy systems could not build instruments dedicated only to fluorescence lifetime imaging. Instead, FLIM was usually offered as one capability inside larger, more complex platforms designed to perform several techniques. These systems could be extremely powerful, but they were not built around FLIM alone.

This shaped access. If a researcher wanted to perform FLIM, they often had to buy into an instrument that could do much more than FLIM. That meant higher costs, larger systems, more complex workflows, and, in many cases, a level of investment that made sense only for major facilities or specialized labs that needed multiple advanced imaging modalities at once.

For researchers who simply wanted to use FLIM, this created a barrier. The technique was available, but not always approachable. The measurement was valuable, but the path to performing it could be too expensive or too complicated.

Today, however, the situation is changing. Interest in fluorescence lifetime imaging is growing across biology, medicine, materials science, photonics, and industrial research. More researchers are beginning to understand that lifetime is not just an extra feature, but a different way of reading fluorescence. At the same time, optical components, detectors, timing

electronics, and data-analysis workflows have evolved. This makes it possible to rethink what a FLIM instrument can be. Instead of treating FLIM as one expensive option inside a broader multipurpose platform, FLIM LABS' goal is to build instruments designed specifically for fluorescence lifetime imaging. FLIM-exclusive systems can focus on what researchers actually need to acquire, reconstruct, and analyse lifetime data, without forcing them to pay for unnecessary complexity. This does not mean making FLIM less rigorous. It means making the route to FLIM more direct.

Democratizing FLIM means lowering the practical barriers that have historically limited its adoption: cost, complexity, integration, portability, and usability. It means creating instruments that can enter existing laboratories more easily, connect with real workflows, and help more users explore lifetime imaging without needing to rebuild their entire setup around a large, closed system. In this sense, accessibility is not a marketing slogan. It is an engineering direction. A more accessible FLIM system has to be compact, reliable, understandable, and precise. It has to preserve the scientific value of lifetime imaging while making the technology easier to adopt.

That is the shift: from FLIM as a specialized capability reserved for a few, to FLIM as a measurement that more researchers can consider part of their everyday toolbox.

The future of FLIM will not depend only on making the most complex instruments possible. It will also depend on making the right instruments possible: accessible enough to bring lifetime information to more questions and more laboratories.



A New *FRAME* for Microscopy



A conversation with openUC2 founder Benedict Diederich on modular microscopy and how collaboration with FLIM LABS could make advanced imaging more accessible.

First of all, could you briefly introduce yourself and tell us about your background?
My name is Benedict Diederich, and I'm currently based in Jena. I'm a father of two and the founder and CEO of openUC2. I've been involved in all kinds of open-source activities for a long time, both in hardware and software. I was also a group leader at the Leibniz Institute of Photonic Technology, where I was strongly focused on democratizing microscopy and making advanced technologies more accessible. That's probably also why I got in touch with FLIM LABS some time ago. We share a very similar vision.

openUC2 is often associated with open, modular microscopy. What problem were you trying to solve when the company started?
I think the starting point was definitely my curiosity. I'm always eager to explore whether we can build machines that are typically considered too complex or too expensive for most people to develop themselves. But beyond that, we wanted to create a modular system that others could benefit from. There are scientific results that are simply not achievable if you don't have access to the right equipment, and access often depends on how much money you have. In the end, it's about democratization: giving people the tools they need and allowing them to experiment, modify things, and build their own solutions. In that sense, I think our approach is very similar to what FLIM LABS is doing. We want to



Benedict Diederich

make technologies that are traditionally expensive or difficult to access more affordable and accessible.

This month's issue of LIFETIME focuses on democratizing FLIM. How does openUC2's FRAME microscope fit into this idea?

The FRAME microscope is essentially the result of a community survey. We asked people which features they would most like to see in a microscope, and the result was a long list of requirements that we have been implementing step by step. The system has now evolved into a fully automated microscope. We originally started with our modular cubes, but those alone were not robust enough for certain applications. So we moved toward a metal structure that could provide greater rigidity and stability. I think things escalated a little along the way! Our initial target price was around €5,000, but the final system became somewhat more expensive. The challenge is that, in optics, compromises are not always enough. For several components, we had to choose more expensive solutions to achieve the performance we wanted.

How does integrating the FLIM LABS add-on expand what the FRAME microscope can do?

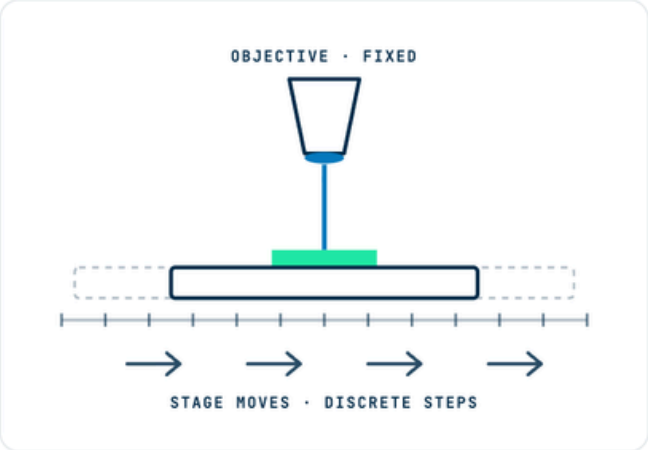
The whole idea behind FRAME is modularity. FRAME stands for Fast and Rigid Automated Microscope Engine. Essentially, it is a metal structure designed to hold our modular optical cubes, combining the rigidity of a fully automated metal frame with the flexibility of our plastic-manufactured components. You get the best of both worlds. The FLIM component works as an inner frame, or optical module, that can be inserted into the microscope almost like a cartridge. The optical interfaces are already defined by FRAME and the UC2 cubes. This means you can develop your optical circuit separately, slide the FLIM module into the system, and have it integrate with the rest of the microscope, including the electronics and control software. That's essentially the idea: a modular platform where advanced imaging capabilities can be added without redesigning the entire instrument.

What new applications could modular microscopy systems such as FRAME unlock, particularly in life sciences and industrial research?
I think the opportunities exist wherever people currently lack access to this kind of microscope. That includes environments where installing or maintaining advanced instruments can be difficult, such as high-safety laboratories, but also regions where access to major microscopy manufacturers or technical support is limited. For example, some manufacturers may not serve every region of Africa. If we can provide an alternative, users could also repair or adapt their own instruments. Because large parts of our system are open source, people can print replacement components, order parts online, or develop improvements themselves. When users need something new, our modular cubes also allow us to create additional components. Especially now, with AI becoming more widely available, I think the possibilities are enormous. It might sound ambitious, but this is really about democratizing cutting-edge research instruments. Things that used to be extremely complicated are now becoming easier for many more people to build and use. And yes, I absolutely believe that combining modular microscopy with FLIM could open new markets and bring capabilities beyond conventional fluorescence measurements. Making these technologies more accessible creates opportunities for applications and users who previously could not take advantage of them.

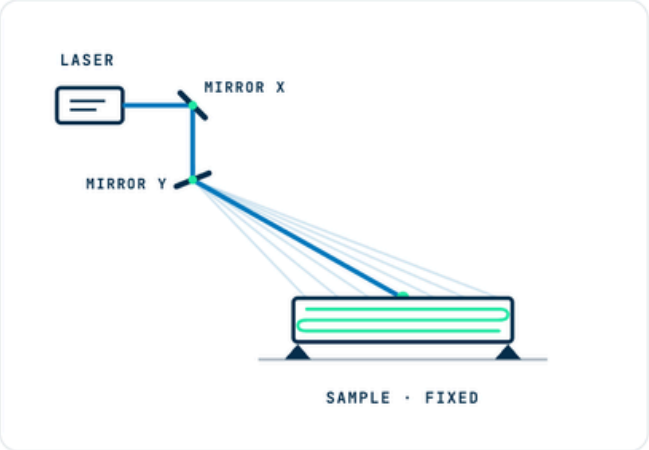
Any last thoughts?
One thing we're particularly busy with right now is developing a digital twin of our microscope systems. The idea is that you can design your optical setup on our online platform, test it, and simulate how the microscope will work before actually building it. This is something we also explored during the workshop. You can first understand how the different components interact, simulate the entire system, and then share your design with others. In a way, we're trying to bring to optical instrumentation something that people working in electronics have been doing for quite some time. And I think the most important part is what happens afterwards. Imagine someone using an openUC2 FRAME system with the FLIM LABS integration. They develop an improvement, perhaps in the software or the optical configuration, and then share it with the community. Other researchers could reproduce that setup, build on those improvements, and potentially publish their results alongside the technical design. That would really be a dream: creating an ecosystem where people don't just use instruments, but continuously improve them and share what they learn.

Learn more about the collaboration between FLIM LABS and openUC2 by scanning the QR Code

TECHNIQUES



MOVING THE STAGE
Mechanical steps, inertia, settling



MOVING THE LIGHT
Two small mirrors, a fluid trajectory

Galvo Scanners: Moving ***Light***, Not the Sample

How fast-moving mirrors can make FLIM scanning smoother, quicker, and easier to integrate into modular microscopy workflows.

Galvo scanners use small moving mirrors to steer a laser beam across a sample. Instead of physically moving the stage point by point, the system moves the light with speed and precision.

This can make scanning faster, smoother, and less mechanically stressful for the sample and the setup. A more stable scanning system can

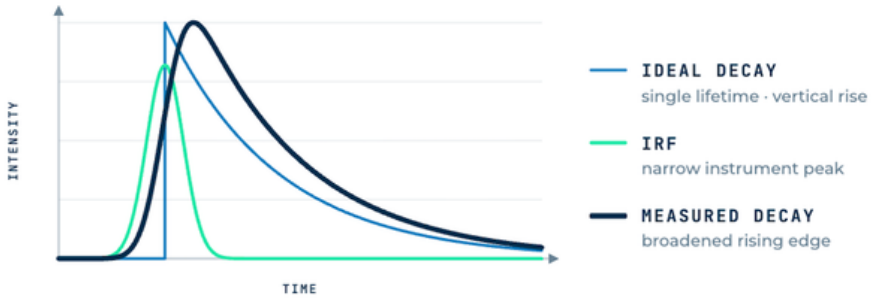
therefore help make fluorescence lifetime imaging more practical and reliable.

For modular platforms such as openUC2-based microscopes, galvo scanning can also support compact and flexible designs, making it easier to integrate scanning modules with FLIM LABS components.

The principle is simple but powerful: keep the sample still, and let the optics do the movement.

Instrument Response Function: The Instrument's *Temporal Fingerprint*

Why the IRF matters when measuring fluorescence lifetime with TCSPC



In an ideal model, a fluorophore with a single lifetime produces a clean exponential decay. In a real TCSPC experiment, the measured curve is never perfectly ideal. This is because the instrument also has a temporal response. The laser pulse is not infinitely short, the detector introduces timing uncertainty, and the TDC adds its own contribution. Together, these effects form the Instrument Response Function, or IRF.

The IRF describes how the full measurement system responds to an ideally instantaneous event. As a result, the measured fluorescence decay contains both the sample's real behaviour and the temporal broadening introduced by the instrument. For accurate lifetime analysis, the IRF must be considered during fitting. Instead of fitting the measured histogram as if it were an ideal decay, the analysis accounts for how the ideal fluorescence decay is modified by the instrument response.

This is especially important when the fluorescence lifetime is close to the temporal resolution of the system. In short, the IRF helps separate what belongs to the sample from what belongs to the instrument.

GET STARTED

Explore Accessible FLIM Solutions

> Bring fluorescence lifetime imaging into your workflow without unnecessary complexity.



FLIM Kit

A focused, ready-to-use FLIM system.



FLIM Upgrades

Add the time dimension to existing optical workflows



Modular Integration

Build flexible FLIM workflows around your research, product, or application.

→ Talk to FLIM LABS

Contact us by sending an email to info@flimlabs.com or via www.flimlabs.com



U-SCREEN

The collaboration between FLIM LABS and Scuola Normale Superiore enters its operational phase, laying the foundations for a joint laboratory dedicated to nanomedicine innovation.

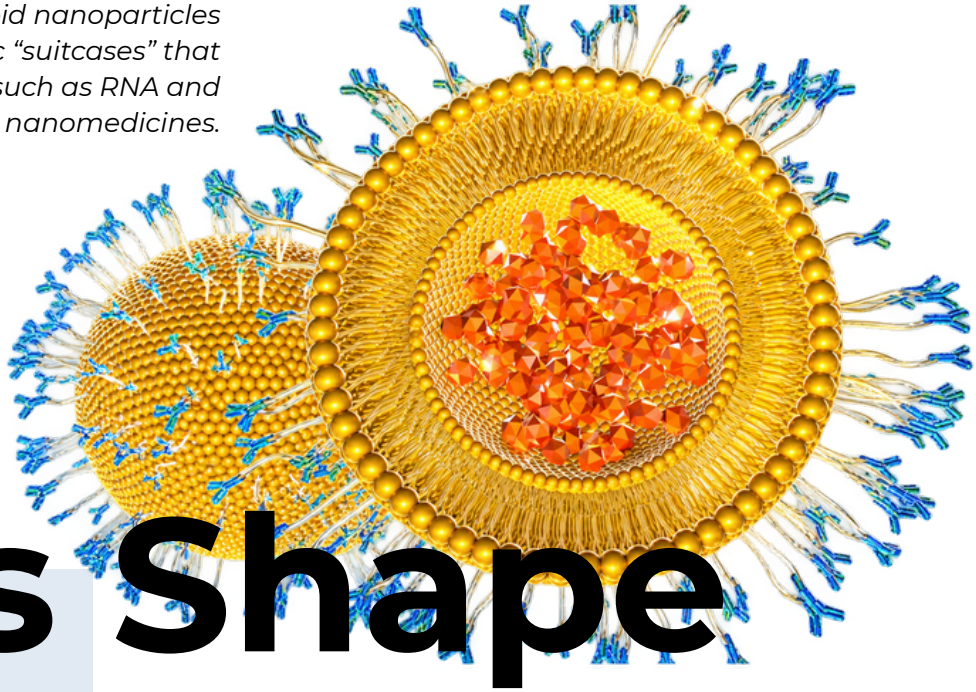
Started in July 2026 and funded by the FISA programme, the Italian Fund for Applied Sciences, U-SCREEN is now entering its operational phase. The project marks an important step in the collaboration between FLIM LABS and Scuola Normale Superiore, within the NEST infrastructure centre in Pisa.

One of the first milestones is the formal presence of FLIM LABS inside the facilities of Scuola Normale Superiore, through the creation of a joint laboratory at NEST. This space will form the basis for a structured collaboration between academic research and technological development.

The goal is to create an environment where research knowledge can gradually translate into innovative solutions for the study and development of nanostructured systems for nanomedicine.

At the same time, work is underway to prepare the laboratory spaces and infrastructure needed for experimental activities, with the aim of making them fully operational in the first quarter of 2027.

This infrastructure work is moving in parallel with the start of the scientific programme. The team is



Conceptual illustration of lipid nanoparticles (LNPs), the microscopic "suitcases" that transport nucleic acids, such as RNA and DNA, in nanomedicines.

Takes Shape

already active in the development and production of nanoparticles for the encapsulation and delivery of DNA and RNA. These first activities represent an essential step toward studying the properties of the formulated systems and preparing for their later characterization, with particular attention to nanoparticle behaviour and the cargo they carry.

"The possibility of bringing together scientific and technological expertise is central to transforming research results into new opportunities for innovation. With U-SCREEN, we are building the conditions for a structured collaboration between FLIM LABS and Scuola Normale Superiore, combining infrastructure development with the launch of experimental activities," says Francesco Cardarelli, scientific lead of the project.

The consolidation of the laboratory infrastructure and the continuation of experimental work will guide the next phase of U-SCREEN. The project aims to strengthen the dialogue between research and innovation, creating a shared foundation for new methods to characterize nanoparticles and supporting the transfer of scientific knowledge toward future applications.

NEXT ISSUE

Coming next month: A Matter of Time

A journey through the technologies that transformed microscopy, from conventional optics to FLIM.



WHAT'S INSIDE

THE EVOLUTION OF MICROSCOPY

Tracing the evolution of microscopy and FLIM's role across technologies.

EXPERT INTERVIEW

Alvaro Crevenna (EMBL) on FLIM's growing role in microscopy facilities and its next frontiers.

FLIM IMAGER SOFTWARE

How FLIM Imager transforms fluorescence lifetime data into phasor-based analysis.



Modular *Microscopy* Meets Lifetime Imaging

How openUC2's FRAME microscope integrates FLIM LABS technology to bring fluorescence lifetime imaging into a flexible, modular platform.

Advanced microscopy often requires complex instruments that are difficult to adapt to new experimental needs. The FRAME microscope, developed by openUC2, offers a different approach. Short for *Fast and Rigid Automated Microscope Engine*, FRAME combines a stable, automated metal structure with interchangeable optical modules, allowing researchers to customize their imaging setup.

Through the collaboration with FLIM LABS, FRAME can now incorporate fluorescence lifetime imaging capabilities using a dedicated add-on. Designed as an interchangeable module, the FLIM system integrates with the microscope's optical interfaces, electronics, and control software.

This modular approach allows researchers to add lifetime measurements without replacing the entire microscope, making advanced imaging more flexible and accessible.

The result is a platform designed to evolve alongside scientific needs, combining openUC2's modular architecture with FLIM LABS' lifetime imaging technology.

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