ICFO

Frontiers Research School:

Physics for Biology and Medicine

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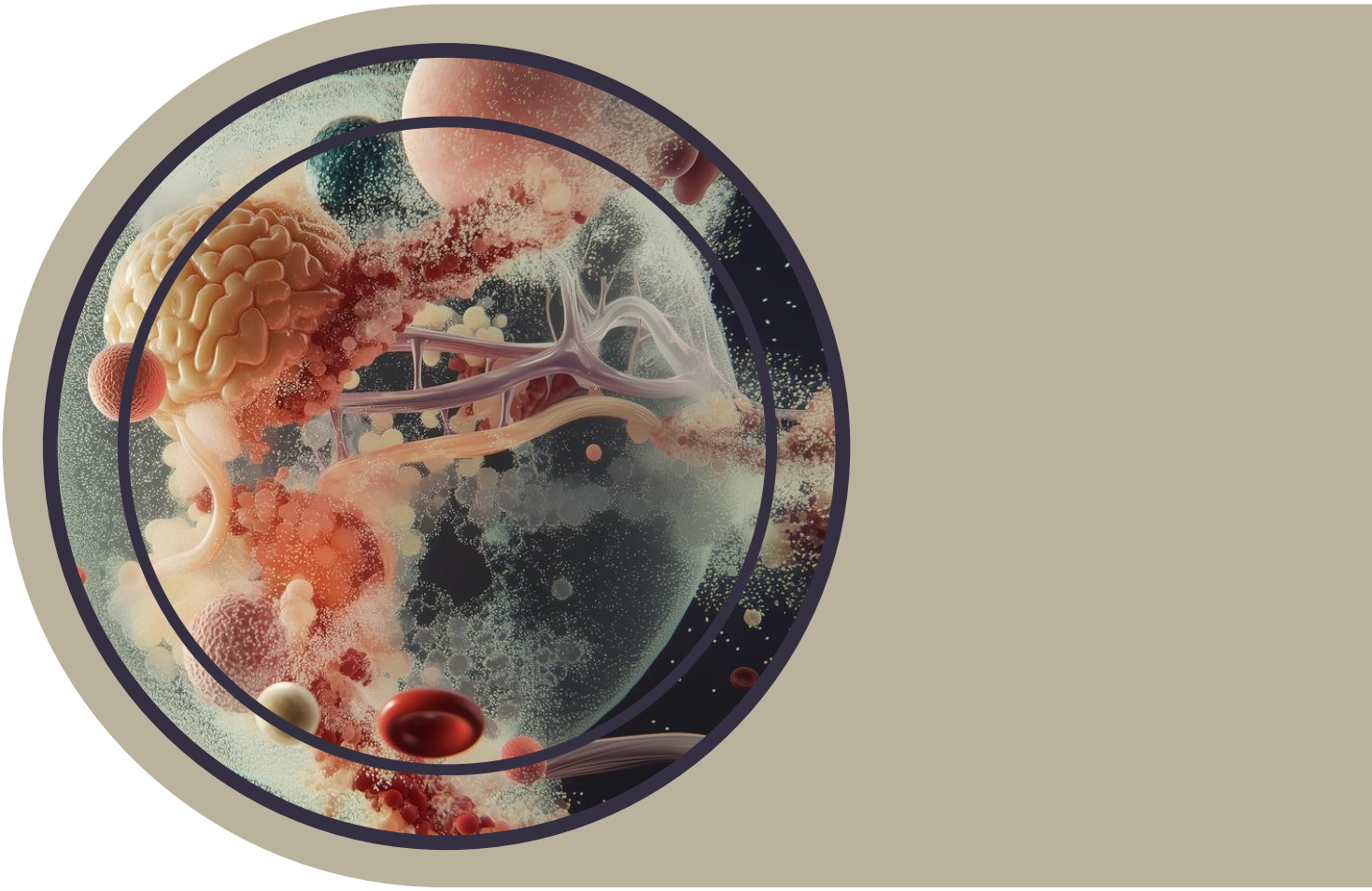
Poster booklet



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Poster session

Wednesday, July 9
14:30 – 16:00
NEST Hall

POSTER 1 – Klaudia Nowacka-Pieszak
Institute of Physical Chemistry PAS/ ICTER

Time-of-flight-resolved interferometric speckle contrast optical spectroscopy (TOF-resolved iSCOS)

Speckle contrast optical spectroscopy (SCOS) is a noninvasive technique used to monitor blood flow and tissue dynamics by analyzing the speckle pattern produced by coherent light scattered by tissue. The speckle contrast varies with the movement of red blood cells, providing information on blood flow and microcirculation. This method is valued for its simplicity, high sensitivity, and real-time monitoring capability in humans in vivo. Recently, interest has grown in extending SCOS using interferometry to enhance sensitivity, allowing for low light level detection and mitigating ambient light interference. Interferometric SCOS indirectly probes optical field autocorrelations from speckle contrast recorded with a slow camera, achieving highest sensitivity when camera exposure matches the sample's decorrelation time. However, unknown a priori decorrelation times make real-time monitoring challenging as blood flow varies between subjects. To address this, we introduce and evaluate time-of-flight-resolved interferometric SCOS (TOF-resolved iSCOS). Implementing TOF-resolved iSCOS with a rapidly tunable laser and an ultrafast two-dimensional camera at 1.1 million frames per second, we mimic multi-exposure acquisitions to achieve time-of-flight resolved speckle contrast. This method estimates the depth-dependent blood flow index, enabling in vivo blood flow monitoring at short source-collector separations. Our setup uniquely compares time-of-flight autocorrelation-based blood flow estimates with time-of-flight speckle contrast analysis, providing guidelines for optimizing SCOS-like monitors. We present validation results from liquid phantoms and human forearm measurements in vivo.

POSTER 2 – Angélica Díaz Díaz
Autonomous University of Querétaro

Obtaining the focal point during pulsed laser ablation in liquids for metal nanoparticles synthesis

One of the main problems of nanoparticle synthesis by using pulsed laser ablation in liquids is the nonexistence of some method that allows to find the focal point in order to determine whether the target is been ablated above-focus, at-focus, and below-focus. According to the zone in which the target was ablated, the nanoparticles will present different properties. This is the reason why a novel method that finds the focal point of a target was implemented. Once the focal point was found, it was possible control in which of the three zones the target would be ablated. Below-focus and above-focues ablations were done at one Rayleigh length (±0.4 mm) far from the focal point. In addition, UV-Vis spectrum of the synthesized nanoparticules was measured. It was observed that depending on the ablation position (above-focus, at-focus, or below-focus), the nanoparticles presented different physical and chemical properties.

Poster session

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POSTER 3 – Akanksha Sharma
Indian Institute of Technology (IIT) Bombay

High-Precision Fabrication of Micro/Nanoneedle Patches Using Two-Photon Lithography for Biomedical Application

Micro/nanoneedles have emerged as promising tools in biomedical applications such as transdermal drug delivery, biosensing, and minimally invasive diagnostics, owing to their ability to penetrate biological barriers with minimal pain. In this study, we present a novel methodology for the fabrication of micro/nanoneedles using two-photon lithography (TPL). This femtosecond laser assisted techniques facilitates fabrication of highly precise micro/nanoneedle structures with sub-wavelength resolution. These TPL-fabricated templates were further used to enable scalable production via micromolding. We have successfully optimized and demonstrated the fabrication process for developing a flexible biopolymer patch for transdermal diagnostics. The proposed fabrication strategy offers high precision and scalability making it highly suitable for emerging applications in transdermal drug delivery, biosensing, and related biomedical fields.

POSTER 4 – Jordi Torres Durall
University of Barcelona

Tailored ultrasound fields for direct light control within samples

A key challenge in modern optics is to rapidly control light deep within a biological sample. As of today, endoscopies are the only technique that can achieve this kind of light delivery. However, they require puncturing the samples with optical fibers, thus being highly invasive. Recent advances in acousto-optics are showing a promising alternative: to generate virtual ultrasonic endoscopes using the acousto-optic effect, allowing fast and targeted deep light delivery while remaining non-invasive. Here, we discuss different hybrid ultrasound-light implementations designed for light control inside samples, highlighting optimal design features and current challenges. We also present the development of a piezoelectric transducer that obviates the need for acoustic cavities and provides micrometric light guiding at MHz frequencies.

POSTER 5 – HANDAN YILMAZ
Istanbul Technical University

Time-Resolved Prompt-Gamma Profiling for Real-Time Verification of Proton-Therapy Dose Delivery

Exploiting the full therapeutic window of proton beams demands sub-millimetre, real-time range verification. Prompt-gamma (PG) emission, generated quasi-instantaneously by proton–nucleus interactions, is a promising in-vivo signature of the beam end-point. We present a comprehensive Monte-Carlo simulation study that quantifies how time-resolved PG profiles can localise the distal dose edge during clinical-energy irradiations.

A detailed GEANT4 model of a 230 MeV proton treatment line—including beam optics, patient-like phantoms and a fast $LaBr_3$(Ce) detector—was developed. Proton microbunch structure was tracked to nanosecond precision, enabling time-of-flight separation of PG events from background. A Python/C++ deconvolution algorithm converted simulated PG-arrival histograms into reconstructed depth-dose curves. Parametric scans assessed the impact of detector timing (1 ns → 100 ps), placement (10–30 cm) and beam energy (70–230 MeV).

With a 300 ps detector at 15 cm, the reconstructed range agreed with Monte-Carlo ground truth to 0.9 mm (1 σ) for depths up to 10 cm. Reducing timing jitter to 200 ps tightened accuracy to 0.5 mm. Sensitivity to setup geometry and material heterogeneities was also quantified.

These purely computational results indicate that time-resolved PG profiling can feasibly provide on-line range verification within clinical tolerances. Hands-on sessions at the ICFO school will guide the experimental realisation, specifically integrating advanced SiPM arrays and coincidence electronics. Ultimately, the technique aims to underpin safer and more efficient proton-therapy workflows.

POSTER 6 – Héctor A. Contreras-Sánchez
University of Toronto

Evaluating the synergistic effects of antiangiogenic therapy and stereotactic body radiation therapy using optical coherence tomography

The anomalous regulation of angiogenesis is now recognized as an important hallmark of cancer, and thus the tumour vasculature and various cell-secreted factors involved in vessel growth are becoming relevant targets in cancer therapy. The use of antiangiogenic therapy (AT) in combination with standard-of-care treatment modalities such as radiation therapy is being investigated as a promising therapeutic approach in both preclinical and clinical trials. Further, with the emergence of stereotactic body radiation therapy (SBRT), and the potential microvascular damage associated with its high doses, possible synergistic effects might exist from concurrent downregulation of angiogenic pathways and delivery of high dose ionizing radiation, but current understanding of the latter dual therapy strategy and its added risks/benefits thus far remains incomplete. Here, we propose a preclinical study using optical coherence tomography (OCT) and fluorescence microscopy to characterize tumour microvascular networks and to evaluate the individual and additive effects of AT and SBRT in pancreatic ductal adenocarcinoma in a dorsal skin window chamber mouse model, with the aim of elucidating the role of tumour vessels in cancer radiobiology and the therapeutic benefits of the concomitant use of angiogenic inhibitors and SBRT.

POSTER 7 – Anulia Mykhaelian
Humboldt University of Berlin

Four-port all-fiber acousto-optic beam splitter and its applications

We report on the fabrication of low-loss fiber null-couplers and we discuss two important applications. Null-couplers are fiber couplers in which the light coupling ratio can be controlled by launching acoustic waves propagating along the coupler waist. Since the presence of the acoustic wave breaks the forward-backward symmetry for propagating light fields, null-couplers can be used to realize all-fiber non-reciprocal devices. For instance, we show that by cascading two null couplers in a Mach-Zehnder interferometer, it is possible to fabricate broadband and low-loss optical circulators. Furthermore, since null-couplers presents very low insertion loss (<1%), we also explore their potential in the fabrication of a high-finesse (>250) fiber ring resonator for enhancing light-matter coupling in nanofiber-based cold atom experiments.

POSTER 8 – Iván de Jesús Rizo Álvarez
Friedrich-Alexander-Universität Erlangen-Nürnberg

Cytotoxicity Evaluation on Jurkat E6-1 and Cell Adhesion Promotion of HeLa on Biomechanical Double-Layer Piezoelectric Nanocomposite for Potential Biomedical Applications

This work presents a proposal for an energy-harvesting nanocomposite for potential biomedical applications. The approach involves embedding Rochelle salt, a piezoelectric material, in a polymeric matrix, utilizing Ecoflex 00-30. Subsequently, this composite is coated with a reinforced PDMS nanocomposite to enhance biocompatibility. The coating was composed of silanized cellulose nanofibers (Si-CNF) dispersed in Polydimethylsiloxane (PDMS) 20:1 (pre-polymer to curing agent) and functionalized with (3-aminopropyl) triethoxysilane (APTES) after surface activation through plasma treatment (UVO). Consequently, cellulose nanofibers are affixed to the surface using APTES to facilitate cell adhesion. The coated composite exhibits a maximum harvested output voltage of 156.8 mV and elastic modulus of 1.286 kPa compared to the uncoated counterpart of 59.5 mV and 0.707 kPa, respectively. Furthermore, the uncoated composite demonstrated significant cytotoxicity on Jurkat E6-1 cells, while the coated composite showed no toxicity at the studied concentrations and promoted good cell adhesion in HeLa. Therefore, the energy-harvesting nanocomposite, with improved biocompatibility, superior electrical output, and positive cell response, shows great potential for diverse biomedical applications, highlighting its feasibility in various medical devices and therapies.

POSTER 9 – Mingxue Sun
Lund University

A Novel TFBG-SPR Sensor for High-Sensitivity miRNA Detection in Cancer

We present a novel Tilted Fiber Bragg Grating-Surface Plasmon Resonance (TFBG-SPR) biosensor for high-sensitivity detection of microRNA (miRNA), aiming to improve early cancer diagnostics. Leveraging hairpin DNA-modified gold nanoparticles (BAS-AuNPs) as specific probes, our platform achieves precise miRNA recognition through refractive index modulation on the fiber surface, producing a distinct spectral shift. The sensor demonstrates a detection limit of 7.94 pM in serum—significantly below the clinical threshold—and offers strong consistency between theoretical predictions and experimental results. Its adaptability to various nucleic acid sequences paves the way for a universal, label-free detection platform. Future development focuses on extending its capabilities to direct detection in whole blood, enhancing its clinical applicability.

POSTER 10 – Martina Caiazzo
University of Naples Federico II

Solid lipid nanoparticles for targeted therapy with Selumetinib to improve treatment of patients with plexiform neurofibromas

Neurofibromatosis type 1 (NF1) is an autosomal dominant disease that affects 1 in 3,000 people worldwide. In most cases, NF1 can cause the development of inoperable and symptomatic plexiform neurofibromas, significantly compromising the quality of life of patients. To date, there are no general therapies for NF1. In the last few years, the drug Selumetinib has obtained approval for clinical use. It is an inhibitor of the activity of specific enzymes MEK1 and MEK2 involved in stimulating cell growth. In NF1, these enzymes are overactive and cause tumor cells to grow in an unregulated manner. Selumetinib has been shown to be effective in reducing tumor volume and cell proliferation. However, its chronic administration can cause side effects (e.g., diarrhea, nausea, vomiting, but also more severe complications like heart failure) and can limit long-term adherence to therapy. This research aims to enhance current Selumetinib-based therapy using solid lipid nanoparticles (SLNs) for targeted and controlled drug delivery. The proposed nanocarrier system consists of a lipid matrix encapsulating Selumetinib, functionalised on the surface with GE11 peptide to selectively target EGF receptor overexpressing on Schwann cells surface to facilitate receptor-mediated endocytosis. Key advantage would be bypassing the gastrointestinal tract, that can be limiting in terms of bioavailability. Moreover, with an in situ approach, a lower dosage could be adopted for the drug. This nanoparticle-based strategy offers a scalable and less invasive approach to improve NF1 treatment outcomes.

POSTER 11 – Elena Vitali
IDIBELL-Bellvitge Biomedical Research Institute

Imaging hematopoietic stem cell nuclei to identify rejuvenating compounds

Hematopoietic stem cells (HSCs) sustain hematopoiesis throughout the lifespan of an organism. Aging of HSCs is associated with a range of cellular and molecular alterations, including changes in their epigenetic landscape and nuclear morphometric features, which ultimately manifest as a functional decline in their ability to maintain hematopoietic homeostasis. Importantly, our lab has previously demonstrated that interventions such as Cdc42 inhibition with CASIN and RhoA signaling blockade via Rhosin can reverse these aging-associated changes, restoring youthful nuclear morphology, epigenetic signatures, and functional competence in aged HSCs.

While DAPI staining does not provide a comprehensive view of the epigenetic landscape, it does reflect key aspects of nuclear architecture, such as heterochromatin distribution and overall nuclear morphology, that change with age. These features can be quantitatively extracted from high-resolution 3D confocal microscopy images using computational tools and are sufficient to classify a cell as young or aged using our newly developed deep learning-based tool, ChromAgeNet.

Building upon these findings, we aim here to test the potential of this imaging-based approach to screen compounds that might functionally rejuvenate aged HSCs. In this project, aged HSCs were treated with a panel of candidate compounds and subsequently analyzed by 3D confocal imaging after staining nuclei with DAPI and immunolabeling selected epigenetic and structural markers known to differ between young and aged stem cells. These markers served as a proxy to estimate the degree of rejuvenation while DAPI-only images were used as a test set for ChromAgeNet.

Preliminary results indicate that selected treatments induce shifts in nuclear morphology and marker distribution toward a youthful phenotype, presenting as well increased ChromAgeNet rejuvenation scores. These findings support the feasibility of using ChromAgeNet and DAPI-based imaging data as a cost-effective tool to screen and rank compounds that target chromatin architecture and potentially restore youthful features in aged HSCs.

POSTER 12 – Marco Accorinti
Polytechnic of Turin

Mathematical Modeling and Molecular Dynamics Simulations of pH-Sensitive pBAE Nanoparticles for mRNA Delivery

Poly(beta-amino ester) (pBAE) nanoparticles are promising vehicles for mRNA delivery, particularly due to their ability to respond to pH variations in biological environments such as tumor microenvironments.

In this project, we use molecular dynamics simulations to explore how pH changes influence the structure and behavior of mRNA-loaded pBAE nanoparticles. The focus is on how protonation states at neutral and acidic pH impact nanoparticle stability, compactness, and potential mRNA release mechanisms.

Key properties such as conformational dynamics, surface charge, and interactions with solvent and ions are characterized. Simulations are calibrated using experimental data to support the rational design of more effective and selective delivery systems.

These results aim to provide molecular-level insights into the pH-dependent behavior of pBAE systems and contribute to the optimization of nanoparticle-based mRNA therapeutics.

POSTER 13 – Valentin Gradisteanu
OneAngstrom

Prediction of pKa for Light-Harvesting Complexes (LHCs) residues in the presence of LHCs-protein and LHCs-pigment, lipid interactions

Accurate prediction of pKa in Light-Harvesting Complexes (LHCs) is essential for elucidating their functions in photosynthesis or photoprotection. However, important pKa shifts occur due to the presence of nearby molecules (residues, lipids, pigments or water) and environmental factors (ionic strength) which difficults the quantitative determination of pKa.

From a structural point of view, pKa is the pH at which a titratable residue is observed in a 1:1 ratio between its deprotonated and protonated states. As such, pKa can only be considered as an ensemble average property. Nevertheless, pKa is generally determined without considering the conformational flexibility associated to the switch in the protonation state. To overcome this challenge, we employ constant-pH Molecular Dynamics (CpHMD) simulations, which make use of λ-dynamics performed in a grand canonical ensemble for the titratable protons. With this approach, we explore the conformational landscape at several pH conditions, producing titration curves from which pKa can be extracted.

For this poster presentation, we present our ongoing work toward developing a robust, data-driven model that connects experimental data with structural information derived from CpHMD simulations. In particular, we focus on determining the effect that the local environment has on the pKa shifts of titratable residues. We show how to gain insight by clustering CpHMD trajectories based on interaction types. This characterization is versatile, which makes it valuable to future implement in the description of de-novo LHCs structures.

POSTER 14 – Boutheina Zender
University of Patras

From Light Harvesting to Energy Dissipation: A Structural Model of NPQ Regulation in Diatoms.

Diatoms are major contributors to global oxygen production and carbon cycling, possess exceptional light-harvesting and robust photoprotective mechanisms. Under high or fluctuating light conditions, they activate photoprotective mechanisms (non-photochemical quenching or NPQ) to dissipate excess excitation energy as heat within their light harvesting complexes Fucoxanthin and chlorophyll a/c binding proteins, or FCPs). The LHCX family of proteins is essential for this photoprotective mechanism, in synergy with factors like the xanthiphyll cycle and transthylakoid ΔpH. Within this synergy, FCP complexes could associate with LHCX proteins, however solid structural and dynamic details of an FCP-LHCX1 interaction are not available. In this study we have employed a computational approach to investigate the dynamics of different FCP-LHCX1 complexes from three diatom species (Phaeodacttylum triconotum, Cyclotella meneghiniana, Chaetoceros gracilis) at different ΔpH states. We have run AlphaFold-based structure predictions and classical molecular dynamics (MD). The analysis is focused on how lumen acidification (from pH 7.0 to 5.5) LHCX1 binding to FCPs and the xanthophyll cycle, specifically the conversion of diadinoxanthin (Ddx) to diatoxanthin (Dtx), triggers conformational changes in FCPs that could possibly can be correlated with photoprotection. Our results reveal pH-dependent conformational transitions indicative of a functional switch from light harvesting to energy dissipation, highlighting specific residues and pigments as key sites for quenching. We propose a structural model for the FCP-LHCX1 complex, highlighting conserved interactions and conformational signatures that align with previous findings demonstrating strong FCP-LHCX1 synergy in energy quenching. By advancing the molecular understanding of NPQ in diatoms we offer potential targets for mutagenesis to engineer improved variants, with broader implications for global CO2 assimilation and bioinspired photosynthetic systems.

POSTER 15 – Emma Martinelli
Politecnico di Milano

Exploring Calcium Dynamics in Plant Tip Growth Using Light Sheet Fluorescence Microscopy

Light Sheet Fluorescence Microscopy (LSFM) is a cutting-edge imaging technique that enables rapid, high-resolution volumetric imaging with minimal photodamage. By illuminating samples with a sheet of laser light and detecting fluorescence perpendicularly, LSFM allows for long-term imaging of live organisms under near-physiological conditions. This makes it particularly well-suited for studying plant development, as seedlings can grow vertically while maintaining their natural behavior.

We applied LSFM to investigate calcium oscillations at the root hair tip in two plant models: Arabidopsis thaliana and Marchantia polymorpha. These oscillations are dynamic signals critical to tip growth, serving as indicators of cellular health and function. In Arabidopsis, a well-established model organism with a fully sequenced genome, LSFM was used in combination with genetically encoded calcium indicators to study calcium dynamics across different genetic backgrounds. By knocking out specific genes, we observed significant alterations in the calcium oscillation patterns, highlighting the direct involvement of those genes in root hair tip growth. This approach demonstrates how LSFM can be used to dissect gene function and investigate the molecular mechanisms underlying plant development.

To gain an evolutionary perspective, we extended our study to Marchantia polymorpha, a liverwort and representative of early-diverging land plants. Unlike Arabidopsis, Marchantia lacks true roots but develops rhizoids: unicellular, root-like structures that serve as an excellent model for studying the early evolution of plant rooting systems. These structures offer insights into how root-like organs first emerged and functioned in anchoring and nutrient uptake during the transition to life on land. These structures are thought to be ancestral analogs to modern roots, and their simple organization makes them ideal for high-resolution imaging. However, conventional microscopy techniques struggle to resolve rhizoids due to overlapping leaf tissue. LSFM overcomes this limitation with its optical sectioning capability, enabling clear visualization of internal structures. Our results revealed calcium oscillation patterns in Marchantia rhizoids that differ from those in Arabidopsis, suggesting fundamental differences in the mechanisms of tip growth between basal and more derived plant lineages.

Together, our findings demonstrate the versatility of LSFM for both functional and evolutionary plant biology, offering insights that may inform crop improvement and deepen our understanding of plant adaptation to terrestrial life.

POSTER 16 – William Alexander Rojas Morales
University of Puerto Rico-Rio Piedras Campus

Deciphering Biology in the Language of Physics and Mathematics

The patch clamp technique is fundamental to understanding electrical signals in living cells.

Patch clamp accurately measures ionic currents across cell membranes, from single-channel activity to whole-cell responses.

It investigates drug action and explores neurological disorders.

Patch clamp electrophysiology remains an indispensable tool at the forefront of light-based approaches to biology and medicine, complementing emerging optical methods to gain a comprehensive view of cellular dynamics.

POSTER 17 – Jonathan David López Lug
Lund University

Design and synthesis of core-shell upconversion particles for optical trapping and imaging applications

Optical tweezers are a non-invasive photonic tool capable of trapping and manipulating microscopic particles with high spatial precision using tightly focused laser beams. Their ability to apply controlled forces at the microscale has made them invaluable in biophysical and biomedical research. To enhance their functionality, we explore the integration of luminescent nanomaterials that allow for simultaneous trapping and optical readout, opening new opportunities in real-time imaging. In this study, we synthesized $NaYF_4$\|Yb\|Er upconversion nanoparticles (UCNPs) as core-emitting materials and with the Stöber sol-gel method, a silica shell structure was grown. The resulting hybrid particles had an average diameter of 870 ± 93 nm. These UCNP@SiO_2 structures are well-suited for optical trapping experiments. Upon introduction into the optical field of a focused near-infrared laser beam, the particles exhibited stable trapping behaviour and emitted visible green light via upconversion luminescence, confirming simultaneous manipulation and detection. The ability to stably trap and monitor luminescent particles demonstrates the potential of these hybrid materials as contrast agents for biophysical applications. By bridging materials science and photonics, this work aims to contribute to the development of integrated optical tools for biomedical research.

POSTER 18 – Benedetta Gavazzoni
Politecnico di Milano

Ex vivo and in vivo Multiscale Imaging via Multimodal Detection of a Fluorinated Nanoparticle: 19F-MRI and Raman Spectroscopy for Intraoperative Precision

Over the past few decades, considerable efforts have been devoted to enhancing the delivery of nanoparticle-based detection systems into solid tumors. In this context, tumor tissue targeting strategies are designed to function as diagnostic tool, potentially improving early tumor detection, enabling personalized disease treatments, and supporting precision surgery. This study presents a bimodal and multiscale approach, based on imaging with 19F-Magnetic Resonance Imaging (19F-MRI) and Raman microspectroscopy, aiming to detect disease sites using targeted biomimetic fluorinated nanoparticles (FNPs). These FNPs, developed by Polimi, contain a single imaging agent composed of 36 19F atoms, called PERFECTA.

First, a 19F-MRI and a spontaneous Raman spectroscopy characterization of the FNPs were performed to track the NPs in biological microenvironments [1]. Successively, Raman in vitro experiments were conducted in highly phagocytic cells incubated with FNPs, allowing the direct intracellular visualization and internalization of PERFECTA. In this way, we overcame the intrinsic limitations associated with MRI's low spatial resolution, still complex for guiding surgical interventions in real-time, by applying Raman microscopy and spectroscopy approaches at tissue and cellular levels. These methods enable detection up to the diffraction limit resolution and allow tracking of the contrast agent without the need for functionalization. Later, PERFECTA was tested and found localized in vivo in BALB/c mice bearing orthotopic mammary tumors using 19F-MRI. Subsequently, an accurate spectral analysis at a smaller scale was performed on ex vivo tumor volumes through in situ Raman techniques.

Our ex vivo model findings open the door to future in vivo investigations: PERFECTA could be used to identify tumors for surgical extraction, and then further characterize the tumor tissue in situ and in vivo through portable Raman tools with fiber-optic probe, allowing intraoperative detection in a label-free modality.

[1] Chirizzi, Cristina, et al. "A bioorthogonal probe for multiscale imaging by 19F-MRI and Raman Microscopy: from whole body to single cells". (2021)

POSTER 19 – Stavroula Elezoglou
National Technical University of Athens

High-precision depth-controlled laser bioprinting of cells in extracellular matrix for three-dimensional structures

Bioprinting is a rapidly expanding additive manufacturing process, which offers great potential for the fabrication of living tissue by precise printing of cells and biomaterials in a variety of substrates.

This technique has the ability to imitate native tissue functions, thereby offering clinical trials to explore new pathways for regenerative medicine. Among the main bioprinting techniques, Laser Induced Forward Transfer (LIFT) offers high degree of spatial resolution, accurate and controlled deposition of bioinks and high post-printing cell viability. Effective bioprinting requires a deep understanding of material properties, especially the rheological behaviour of bioinks, which is critical for achieving the desired outcomes. Rheological characterization of these materials is essential to understanding their behaviour under bioprinting conditions. LIFT technique utilizes a wide range of soft biomaterials, giving the ability to generate printed structures containing cells, which proliferate for several days post printing. These biomaterials can be controllably deposited in a variety of substrates. Specifically, in this study, two cell-laden bioinks with low and high number cells densities are printed in a controlled depth inside an Extracellular Matrix (ECM) by tuning the laser energy. Hence, by using light and guiding it with the proper optical set up, controlled depth immobilization of cells in desired depth inside ECM, can be achieved. All bioinks were characterized based on their rheological behaviour, using a microfabricated rheometer-viscometer on-a-chip. To investigate the transfer dynamics, a high-speed camera has been integrated in the LIFT set-up, enabling the monitoring of the immobilization phenomenon within the ECM and highlighting important characteristics of the propagation of the jets during printing.

The morphological characteristics of the two sequential and distinct cell-laden jets are examined in detail during the printing process. This study showcases the ability to precisely deposit cells at different depths exceeding 2.5 mm inside a soft matrix substrate, to fabricate any desired cell-laden architecture for bio-engineering applications

POSTER 20 – Nihit Saigal
European Molecular Biology Laboratory, Heidelberg

Development of a cryo-super-resolution microscope for cryo-correlative light and electron microscopy (cryo-CLEM)

Cryo electron microscopy (cryo EM) has been at the center of many new advances and discoveries in biology. The ability to freeze biological samples in vitreous non-crystalline ice, allows us to study biological matter in its native unperturbed environment with molecular resolution. It avoids using chemicals to fix the samples which has been shown to perturb the native environment. This has allowed us to understand the structure-function relationships in the sub-cellular context and also to study interactions between sub-cellular structures and proteins which provided deep insights into the mechanisms governing different processes of life. In-spite of the progress made so far, cryo EM is limited in its ability to provide specificity of the sub-cellular structures and to identify rare-events. One approach to overcome these limitations is to combine it with light microscopy and perform correlative light and electron microscopy (CLEM). So far, there have been rapid developments for cryo-CLEM. However, when correlating light and electron microscopy images, one needs to mind the resolution gap imposed by the wave nature of light or the diffraction limit. One way to overcome the resolution gap is to develop techniques for cryo superresolution microscopy (cryo SRM) and correlate it to cryo EM. For localization-based cryo SRM techniques, there are two possible approaches based on the design of the cryostat used for cooling the vitrified samples. These are open and vacuum based cryostat designs, each with its own advantages and drawbacks. In this poster, I will present a theoretical comparison between the two types of designs and discuss the planning and progress in building a vacuum-cryostat based cryo single molecule localization microscope (cryo-SMLM) to study vitrified biological samples.

POSTER 21 – Ivan Coto
Harvard Medical School

Super-resolution fluorescence lifetime imaging microscopy

Fluorescence lifetime imaging microscopy (FLIM) is a powerful bioimaging technique to advance biomedical research. When combined with super-resolution microscopy, it enables better separation of labeled fluorescent structures with similar emission spectra through a straightforward implementation. So far, these implementations have been limited to specific fluorescent dyes and imaging buffers in single-molecule localization microscopy or to specialized equipment such as stimulated emission depletion microscopy. In this work, we further enhanced the spatial resolution of confocal and widefield FLIM images by applying a computational super-resolution radial fluctuation approach. Frequency-domain fluorescence lifetime imaging was implemented by coupling the vTAU Lambert FLIM camera to an inverted widefield fluorescence microscope. Meanwhile, time-domain confocal FLIM was implemented using a time-correlated single-photon counting (TCSPC) card. Proof of concept was demonstrated by improving the spatial resolution of mitochondria and tubulin filaments in fixed cells. The precision of lifetime measurements was also enhanced. This approach aims to simplify super-resolution FLIM implementation and make it more accessible to users.

POSTER 22 – Maria Helena de Donato Pérezz
Institut de Biologia Molecular de Barcelona (IBMB-CSIC)

Balancing genomic tension: cohesin and rna polymerase II coordinate topoisomerase activity and chromatin architecture

DNA supercoiling arises naturally during transcription and replication and must be resolved to maintain genome stability and allow proper gene expression. Topoisomerases (Tops) relieve this torsional stress, but how they are selectively recruited to specific genomic regions remains poorly understood. Emerging evidence suggests that chromatin loops formed by cohesin — and possibly coordinated with RNA Polymerase II (Pol II) — serve as organizational hubs that concentrate supercoiling and Tops' activity. Indeed, Tops accumulate at loop anchors, where cohesin is enriched, and these sites show increased Top-dependent DNA breaks, suggesting a dual role as regulatory sites for the resolution of supercoiling and fragile chromatin domains.

To address the mechanisms underlying this interplay, I combine super-resolution imaging (STORMi, SMTii) with molecular and genomic tools (ChIP-seqiii, RNA-FISHiv, and a custom-developed method called MiOSiv). These approaches allow me to study how cohesin and Pol II regulate Tops' function and how this impacts chromatin topology and gene transcription

Key words: topoisomerase, cohesin, chromatin loops, transcription, super-resolution imaging

POSTER 23 – Anna Christoforidou
Lund University

Advancing Nanowire-Based Optical Biosensing: Toward Microscope-Free Detection Using Commercial Camera Chips

Semiconductor nanowires with a high refractive index exhibit waveguiding properties that can enhance the excitation and quantum yield of surface-bound fluorescent molecules, while also directing and improving the emission of optical signals. This characteristic has been shown to significantly boost the performance of optical biosensing platforms, particularly when combined with advanced image analysis techniques.

In this work, we aim to further explore and extend the signal-enhancing potential of nanowires by eliminating the need for a traditional fluorescence microscope. Instead, we propose a simplified detection system based on a bare, commercially available camera chip. While this shift introduces engineering challenges and increases system complexity, our initial results are promising. Control experiments support the feasibility of the approach and clearly indicate enhanced signal detection.

With continued development, we envision a compact, cost-effective, and user-friendly biosensing platform suitable for various point-of-care or at-home diagnostic applications. This work not only supports the adoption of the aforementioned nanowires as a standard in the biosensing community but also takes a step toward making high-performance optical biosensing more accessible beyond specialized laboratory environments

POSTER 24 – Ana Radovic
University of Èvry – Paris Saclay

A Microchamber for Long-Term Electrotaxis Studies

Electrotaxis, also known as galvanotaxis, is the directed migration of cells in response to an applied electric field, playing a critical role in wound healing, neural regeneration, and cancer metastasis. A recently proposed mechanism suggests that electrotactic responses are driven by charged membrane proteins, which motivates us to explore its connection to the membrane potential. While microfluidic platforms have been widely employed to study electrotaxis, current designs face significant limitations when applied to fluorescently tagged mammalian cells with low absolute signals and small relative changes. These challenges include environmental instability over extended periods, working with high numerical aperture objectives, high background fluorescence, mechanical stress during cell seeding, and spatial constraints in microscope-compatible setups.

In this study, we present a novel microchamber optimized for long-term electrotaxis and live imaging studies. Our design integrates low-autofluorescence materials, precise environmental control, and stress-free cell seeding strategies to improve experimental reproducibility and imaging quality. The chamber supports low-flow perfusion (~1–5 µL/hour) with optimized gas exchange, ensuring stable conditions for live-cell imaging. We compare the performance of conventional perfusion systems—utilizing pumps, PDMS, and tubing—with a novel passive perfusion approach that incorporates 3D-printed resin and biocompatible tape. Experimental validation focuses on flow stability, electrotaxis efficiency, and cell viability. This platform is envisioned to advance electrotaxis research in cell models and enhance studies on neural regeneration, cancer metastasis, and tissue engineering.

POSTER 25 – Nerea Martos Guillamí
Institut Curie

Impact of mechanical forces on membrane lipid nano-partitioning: Role on interferon gamma receptor functions

The plasma membrane (PM) serves as the primary barrier between the cell's interior and environment, integrating soluble and physical signals. Its nanoscale organization plays a key role in the spatiotemporal control of receptor signaling and biological activity. Growing evidence demonstrates that the heterogeneity and properties of the PM can be perturbed by mechanical forces in physiological and pathological contexts, such as the tumor microenvironment. Interferon gamma (IFNγ) is a key cytokine in tumors that activates the JAK/STAT signaling pathway through its binding to its cognate receptor (IFNγR). It is known that IFNγR functioning depends on its dynamic partitioning into specific sphingomyelin/cholesterol (SM/Chol) nanodomains, and mechanical forces are likely to affect the nano-organization of the PM, but very few is known about the crosstalk between them. In this project, we investigated the unexplored role of mechanical forces on lipid nano-partitioning at the PM and how it can modulate IFNγR functions. Therefore, we applied stretching or hypo-osmotic shock to induce membrane tension increase and we monitored the activation status of JAK/STAT pathway upon IFNγ stimulation. To follow the dynamics of the PM lipid landscape in this context, we used fluo-labelled probes derived from toxins, such as OlyA for SM/Chol complex and D4 for free Chol, and from domains of intracellular proteins, such as GRAM, that binds to Chol on the inner leaflet of the PM. In this context, we observed a decrease in JAK/STAT activation in cells under mechanical stress, as well as changes in the lipid pools in both leaflets. These preliminary results suggest that the nano-organization of PM lipids is perturbed upon mechanics which may influence the signal transduction.

POSTER 26 – Tobias Gundlach
Institut Fresnel

Radiometric Single Molecule Orientation Localisation Microscopy based on Back Focal Plane Splitting

In single-molecule localization and orientation microscopy (SMOLM) there are currently several techniques offering partial or full 3D estimation of the parameters, however, there are still limitations, such as: polarization distortions and optical aberrations that require extensive calibration and/or extra elements for compensation; computational expensive point spread function (PSF) fitting; and need of complex or hard-to-align optical setups. In this work, we present a novel technique that relies on the splitting of the light collected at the back focal plane (BFP) of the setup and that is designed to be more robust to tackle the previous issues. By segmenting/probing the BFP, the 3D orientation of emitters can be estimated radiometrically, thus not requiring complex data analysis and which can be implemented in a simple in-line setup. The core component of this technique is a custom-made prism segmenting the BFP into different sections (channels) of a single camera detector. Additionally, this approach offers in-depth position, z, estimation for single emitters, in a similar fashion as light field microscopy techniques. First experimental results demonstrate the system's ability to qualitatively distinguish populations of single fluorophores' oriented differently under varying illumination conditions. Lastly the z-sensitivity of the system is validated quantitatively. Thus, this study provides a proof of principle for BFP splitting as an accessible SMOLM technique.

POSTER 27 – Ana Sánchez Ferrón
ICFO

Adaptation of pH-Jump Visible Transient Absorption Spectroscopy for Investigating Photosynthetic Proteins

Non-photochemical quenching (NPQ) is a photoprotective process in plants that safely dissipates excess absorbed solar energy as heat to prevent photooxidative damage to the photosynthetic apparatus. NPQ is proposed to be activated by conformational changes of the light-harvesting complexes (LHCs), which activate dissipative mechanisms. These structural changes are triggered by the light-dependent acidification of the luminal space of the photosynthetic membrane. However, real-time observation of the pH-dependent activation of dissipative mechanisms remains challenging.

Towards this goal, the Photon Harvesting in Plants and Biomolecules group at ICFO has developed a novel time-resolved spectroscopic method called pH-Jump Visible Transient Absorption Spectroscopy (pH-VISTA) [Li et al. ChemrXiv 2024]. pH-VISTA is a three-pulse ultrafast technique that allows for the investigation of changes at the level of excited-state dynamics following a controllable, rapid pH change. However, the photoacid used to trigger the pH change and characterized so far, 2-nitrobenzaldehyde, quenches photosynthetic pigments in the LHCs. To overcome this challenge and further develop the use of pH-VISTA for LHCs, we studied multiple photoacids with different functional groups and assessed their ability to modulate pH without disrupting LHCII's function. Our results will extend the application of pH-VISTA for photosynthetic proteins and provide a database for selecting photoacids based on their different properties.

POSTER 28 – Leon Kasperek
ICFO

Investigating Axonal Transport Mechanisms of MEC-2 Condensates in C. elegans Using Single-Particle Tracking and Advanced Imaging Techniques

The physical state of proteins within biomolecular condensates modulates cellular function, yet the underlying mechanisms remain unclear. In neurons, such condensates are known to play essential roles in various processes, but how they are transported along axons is still poorly understood. In this project, we investigate the axonal transport of MEC-2 condensates in the mechanosensory neurons of Caenorhabditis elegans. MEC-2 is a protein that forms biomolecular condensates and undergoes a liquid-to-solid phase transition, modulating its function in force transmission during the sense of touch. The interdisciplinary approach aims to find the biophysical principles underlying intracellular condensate transport and to elucidate their role in neuronal mechanosensation.

To explore this process, we apply single-particle tracking in live, immobilized animals combined with advanced imaging techniques to quantify the mobility of individual condensates along axons. In order to determine the molecular mechanisms involved, we use RNA interference targeting motor proteins, complemented by behavioral touch assays and fluorescence microscopy. Our preliminary results show that knockdown of a specific motor protein leads to a reduced average number of mobile condensates per neuron, as well as a lower ratio of mobile to immobile condensates. These changes are accompanied by reduced touch sensitivity in behavioral assays and altered MEC-2 condensate transport dynamics, indicating a direct link between condensate trafficking and mechanosensory function.

POSTER 29 – Nefeli Stamouli
ICFO

Evaluating Non-Periodic Filter Designs for Phasor-Based Fluorescence Unmixing.

Accurate separation of spectrally overlapping fluorophores remains a central challenge in multi-component fluorescence microscopy. Hyperspectral and fluorescence lifetime imaging (FLIM) techniques have been widely used to address this problem, but they often require complex instrumentation, long acquisition times, or intensive data processing. Phasor analysis has emerged as a powerful method for unmixing fluorescence signals, and recent approaches have demonstrated its implementation using sine and cosine (S/C) spectral filters. In this project, we explore an extension of the phasor framework by investigating alternative, non-periodic filter profiles, with the aim of evaluating their suitability for spectral unmixing in systems with overlapping fluorophores. Performance will be assessed through comparisons with established approaches, including hyperspectral and FLIM-based methods. Our goal is to define the operational limits and advantages of these alternative filters. By exploring these new filter designs, the project contributes to broadening the scope of phasor analysis and reducing the dependence on more complex imaging systems in fluorescence-based biomedical research.

POSTER 30 – Daniela Patiño Vélez
Centre for Applied Physics and Advanced Technology (CFATA-UNAM)

Development of a Thermo-Responsive Biopolymer Platform for the Attachment of Light-Harvesting Complex II (LHCII) and Photophysical Assessments

Light-Harvesting Complexes (LHC) have been extensively studied, yet key aspects of their photoprotective behaviour remain unresolved—particularly under high light intensities, where they activate non-photochemical quenching (NPQ) to dissipate excess energy as heat. Understanding these mechanisms is important for comprehending how photosynthetic organisms regulate energy and could, in the long term, inform the design of nanoscale systems for efficient solar energy utilization. Conventional in vitro studies often rely on solubilized LHCII trimers in detergent micelles or rigid thin films, which do not accurately replicate the native, dynamic lipid-protein interactions found in thylakoid membranes. These artificial environments can limit protein mobility and alter functional conformations, highlighting the need for a biomimetic platform that supports structural flexibility, protein integrity, and nanoscale spatial arrangement. To overcome these challenges, a thermo-responsive, biomimetic platform composed of bacterial nanocellulose, poly(N-isopropylacrylamide) (polyNIPAM), and graphene oxide (GO) is proposed. In this composite, nanocellulose provides a soft, porous, and biocompatible 3D matrix, while GO sheets offer an increased surface area for protein attachment and act as local photothermal modulators. The polyNIPAM nanoparticles, sensitive to temperature changes, function as dynamic spacers to control inter-complex distances. Additionally, GO's fluorescence quenching capacity may enable real-time monitoring of LHCII-GO proximity through modulation of emission intensity. This platform offers a method for recreating key aspects of the photosynthetic microenvironment in vitro and could serve as a model to explore energy dissipation mechanisms with nanoscale precision.

POSTER 31 – Martín Fernandez Campo
ICFO

Tubulin interacts with mechanosensitive biomolecular condensates and conveys forces during touch

Biomolecular condensates are viscoelastic entities capable of sustaining and transmitting forces at scales critical for cellular homeostasis. One example is MEC-2, which, via its intrinsically disordered C-terminal domain, forms biomolecular condensates within the axons of touch receptor neurons in the nematode Caenorhabditis elegans. In these neurons, MEC-2 participates in the mechanotransduction pathway mediating gentle touch sensation. Previous hypotheses suggest that mechanical forces are transmitted from the microtubule cytoskeleton to specific mechanosensitive ion channels through MEC-2 condensates; however, direct evidence connecting MEC-2 with microtubules remains elusive. In this study, we present an in vitro exploration of the interplay between tubulin and MEC-2 biomolecular condensates. Making use of novel active optical tweezers microrheology routines we elucidate potential interactions between MEC-2 and tubulin that tune the mechanical properties of MEC-2 biomolecular condensates.