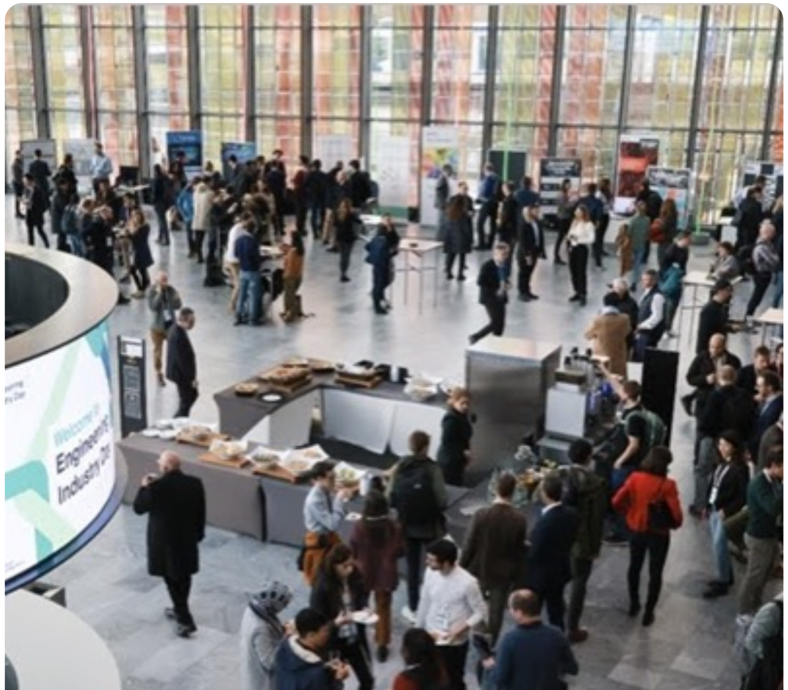
EPFL

Engineering in Medicine



Jean-Philippe Thiran
School of Engineering

ETH Domain Human Health Day 2026

August 20, 2026

School of Engineering (STI) — strategic themes

01 Life & Health Sciences

02 Intelligent Systems & AI

03 Sustainability & Energy Science

04 Digital Transformation

05 Fundamental Research

01 Life & Health Sciences

INSTITUTES · CENTERS · TOPICS

- **Inst. NeuroX**
- Inst. Bioengineering
- **Center on Imaging**
- **Section on NeuroX**
- (STI, SV, IC)

02 Intelligent Systems & AI

INSTITUTES · CENTERS · TOPICS

- AI ↔ Science
- Robotics
- **IEM Institute**
- **EPFL AI Center**
- (STI, IC, SB, SV, ENAC)

03 Sustainability & Energy Science

INSTITUTES · CENTERS · TOPICS

- **Energy Center**
- **EcoCloud Center**
- **Center Adv. Manufacturing**
- Sustainable materials
- Energy storage
- Hydropower

04 Digital Transformation

INSTITUTES · CENTERS · TOPICS

- Intelligent machines
- Data science, AI
- Adv. Manufacturing
- **IEM Institute**
- **SDSC**
- **EPFL AI Center**

05 Fundamental Research

INSTITUTES · CENTERS · TOPICS

- Imaging
- Quantum technology
- Core curriculum
- **QSE Center**
- **Section on QSE**

(STI, IC, SB)

School of Engineering (STI) — strategic themes

01 Life & Health Sciences

02 Intelligent Systems & AI

03 Sustainability & Energy Science

04 Digital Transformation

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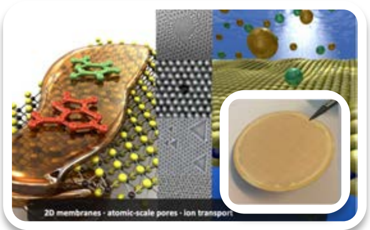
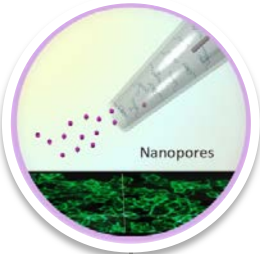
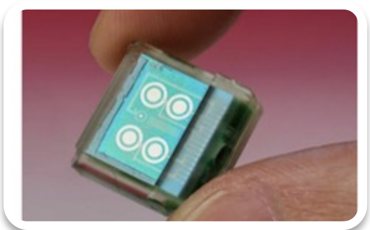
Engineering in Medicine - devices and sensors - from nano to macro

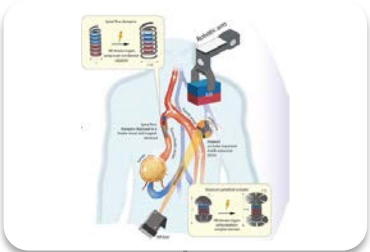
NANO → MACRO

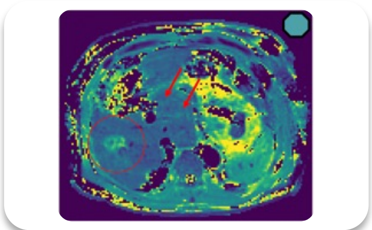
Molecular sensing, smart devices and clinical imaging are connected by scale.











01

Nano-engineering

- Nanotechnologies
- Nanophotonics

02

Molecular sensing

- Bio-chemistry
- Quantum sensors

03

Microsystems

- Microfluidics
- Nano-electronics
- Bioelectronics

04

Intelligent devices

- Micro-robots & Advanced manufacturing
- Motion sensors & signal processing

05

Clinical systems

- X-ray & MRI systems & methods

LABORATORY OF NANOSCALE BIOLOGY

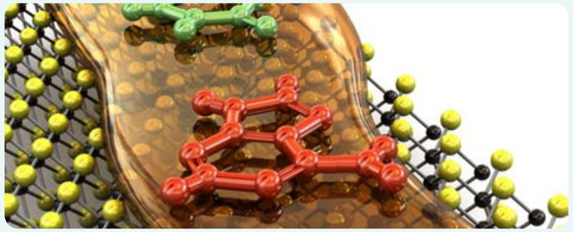
Nanopores turn molecular and ionic motion into function

Prof. Aleksandra Radenovic · single-molecule biophysics, nanofluidics and 2D materials

SINGLE-MOLECULE SENSING

Nature Communications 2019 · Nature Protocols 2019

ATOM-THIN SENSOR



IONIC-CURRENT SIGNAL

A nanometre-scale pore converts molecular passage into an electrical fingerprint.

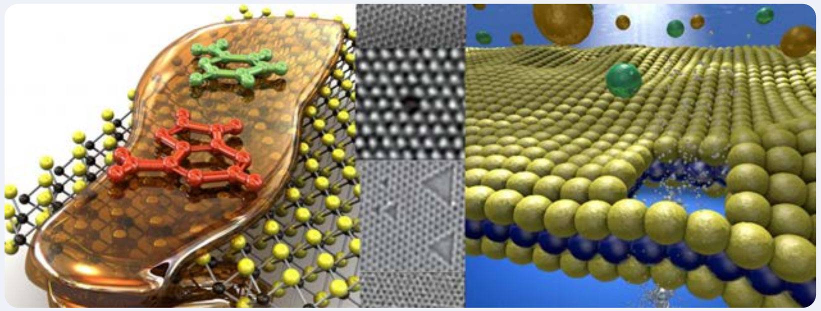
BIOLOGICAL INFORMATION

Read single molecules

Detect molecular identity, conformation and DNA topology without ensemble averaging.

ION TRANSPORT BEYOND SENSING

Nature 2016 · Joule 2019 · current EPFL research direction



OSMOTIC ENERGY

Harvest osmotic energy

Use selective ion transport through 2D nanopores to convert salinity gradients into power.

IONTRONIC COMPUTING

Compute with ions

Nanopore and nanofluidic systems provide ionic analogues of memory and logic.

EPFL

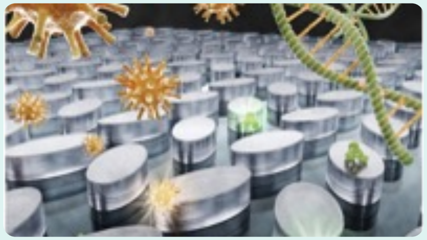
BIONANOPHOTONIC SYSTEMS LABORATORY

Nanophotonics becomes bioanalytics through an integrated toolkit

Prof. Hatice Altug · next-generation biosensors, imaging and spectroscopy for scientific and clinical impact

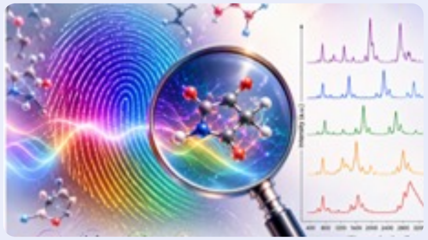
MISSION Combine nanophotonics, assay integration and data analysis to detect, image and characterize biological systems.

METASURFACES

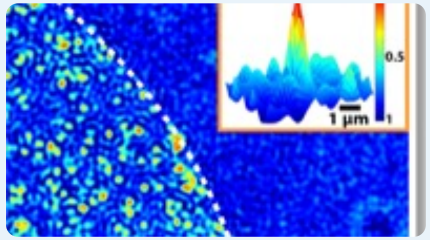


NANOFABRICATION

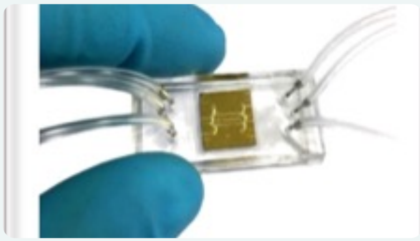
SPECTROSCOPY



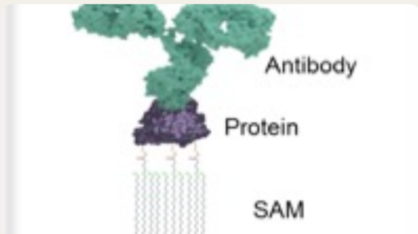
IMAGING



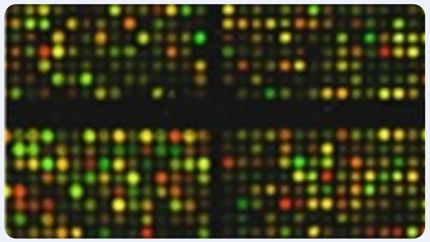
MICROFLUIDICS



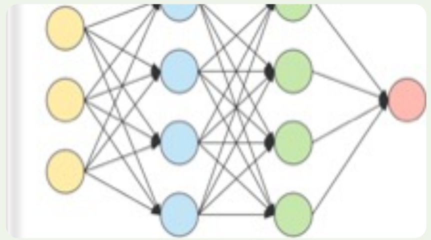
SURFACE CHEMISTRY



MICROARRAYS



DATA SCIENCE



EPFL

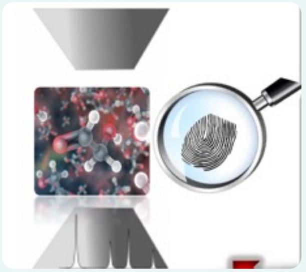
Impact requires the full chain—from nanofabrication and surface chemistry to microfluidics, imaging and data science.

Four directions move the toolkit toward impact

Prof. Hatice Altug · spectroscopy and cell analysis connect to diagnostics and reconfigurable photonic devices

SURFACE-ENHANCED VIBRATIONAL SPECTROSCOPY

- Molecular fingerprints · IR · Raman · CD
- Hyperspectral imaging
- Conformation · chirality
- Real-time IR · aqueous media

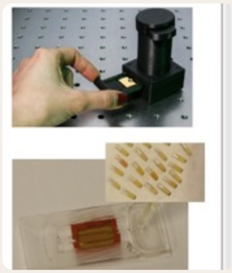


SINGLE-CELL & ORGAN-ON-CHIP TECHNOLOGIES

- Cell screening · profiling
- Secretion · intracellular dynamics
- Cell interactions · biomimetic surfaces · organoids

POINT-OF-CARE TECHNOLOGIES

- Portable · rapid · multiplexed
- Integration · miniaturization
- Optofluidics · lab-on-chip
- Serum · plasma · clinical use



NOVEL NANOPHOTONIC DEVICES

- Active · reconfigurable optics
- Polarization · chirality · encoding
- Nonlinear · quantum effects
- 2D materials · GST · hybrids

LABORATORY OF CHEMICAL NANOTECHNOLOGY

Chemical nanotechnology links molecular insight to patient care

Prof. Nako Nakatsuka · translational chemical biosensing for human health

MISSION

Chemical nanotechnologies for unmet needs in human health

New biorecognition elements and sensing platforms **make dynamic chemistry measurable**—from cells and tissues to patients.

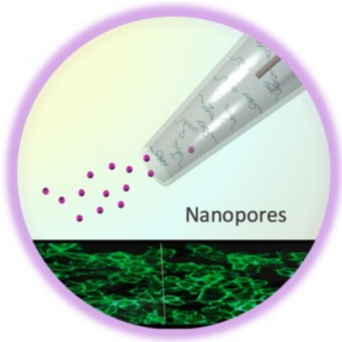
ONE RESEARCH ARC

01	**Probe**	Neurochemistry in cells and tissues
02	**Sense**	Chemical flux inside the brain
03	**Translate**	Biomarkers in clinical samples

THREE CONTEXTS · THREE SENSOR PLATFORMS

Cells & tissues

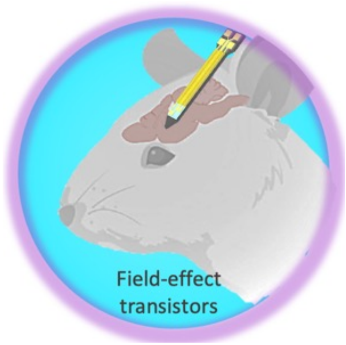
Neurochemical detection



Schlotter et al. · ACS Nano · 2024
Stuber et al. · ACS Nano · 2023
Nakatsuka et al. · Mol. Psychiatry · 2021

In the brain

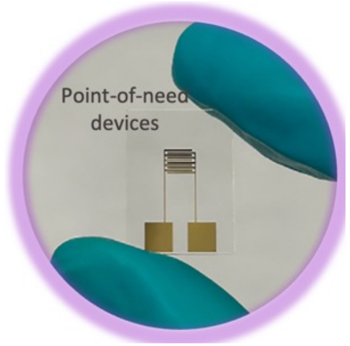
Neurochemical sensing



Nakatsuka · Methods Mol. Biol. · 2022
Zhao et al. · Sci. Adv. · 2021
Nakatsuka et al. · Science · 2018

Clinical samples

Biomarker tracking



Wang et al. · Angew. Chem. Int. Ed. · 2026
Gatterdam et al. · Nat. Nanotechnol. · 2017

SENSING ACROSS LENGTH SCALES

NANOSCALE → MICROSCALE → MACROSCALE

From molecular recognition to practical monitoring tools

EPFL

ADVANCED QUANTUM ARCHITECTURE LAB

Cardiovascular imaging without ionizing radiation

Prof. Edoardo Charbon · time-resolved optical sensing with picosecond SPAD imaging

CLINICAL PROPOSITION

CURRENT PRACTICE

Ultrasound imaging
X-ray imaging: CT or angiography

→

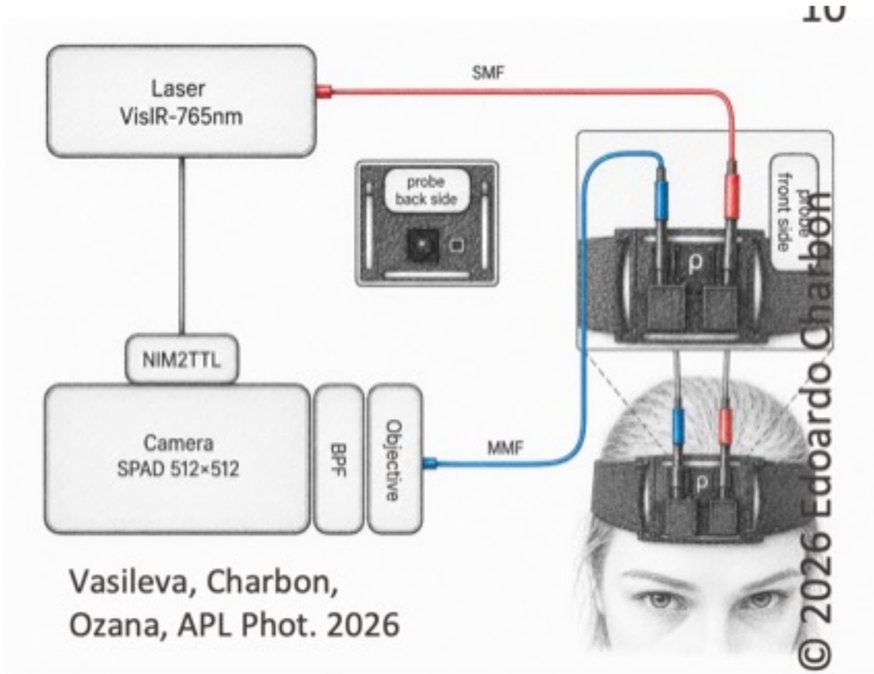
PROPOSED OPTICAL SYSTEM

Comparable resolution
Real-time operation
No ionizing radiation

TIME-RESOLVED OPTICAL PIPELINE

01	**Illuminate**	Pulsed visible-red laser source
02	**Detect**	512 × 512 SPAD image sensor · picosecond timing
03	**Infer flow**	Time-domain speckle contrast optical spectroscopy
04	**Reconstruct**	Richardson–Lucy deconvolution

OPTICAL SETUP · MODEL · REAL-TIME SIGNAL



Vasileva, Charbon & Ozana · APL Photonics · 2026

EPFL

LABORATORY FOR BIOMEDICAL MICROFLUIDICS

Miniaturized assays turn scarce patient material into decisions

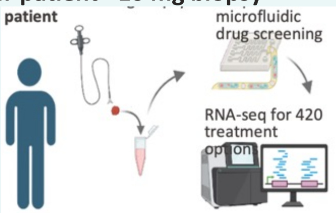
Prof. Christoph Merten · single-cell assays and high-content screening

PERSONALIZED CANCER THERAPY

Nature Comms 2018 · Small 2020 · Nature Comms 2022 · Nature Protocols 2022

PATIENT MATERIAL

Cancer patient · 10 mg biopsy



→

420 TREATMENT OPTIONS

Droplet microfluidic drug screening + RNA-seq

Identify the best possible treatment for each patient, at any stage of disease.

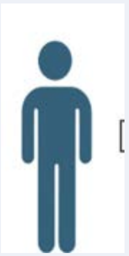
→

CLINICAL TRANSLATION · EPFL STARTUP (2023)

ANTIBODY DISCOVERY

PNAS 2012 · Nature Biotech 2014 · Cell Chem Biol. 2017 · Nature Protocols 2023 · PNAS 2024 · PNAS Nexus 2025

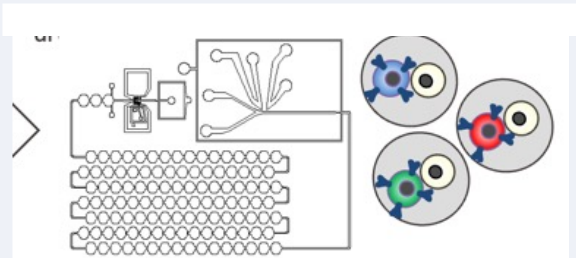
HUMAN REPERTOIRE



B-cell / antibody repertoire of 10^7–10^9 different clones

→

DROPLET MICROFLUIDICS



→

TARGET DECISION

Binding or inhibition of a medically relevant drug target?

→

EMBL STARTUP (2017)

VERAXA

now traded on NASDAQ

EPFL

NANOELECTRONIC DEVICES LABORATORY

Wearable biosensing detects highly diluted biomarkers in interstitial fluid

Prof. Adrian Ionescu - Two sensing interfaces · one real-time capacitive detection strategy

REAL-TIME CAPACITIVE DETECTION | EIS · lock-in amplification · AC sensing of highly diluted proteins and hormones

01

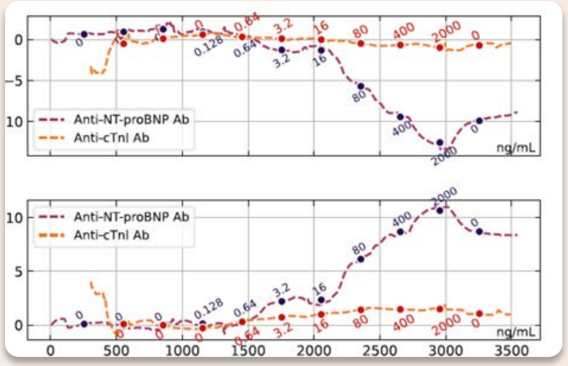
NT-proBNP · CARDIAC BIOMARKER

Collaboration with Xsensio SA

LIMIT OF DETECTION

1 ng/mL

in 1× PBS



- SENSING INTERFACE
  Antibody-on-gold electrodes
- SIGNAL STRATEGY
  Differential measurement
- STABILITY
  Drift correction

Lotte de Schriever et al. · IEEE Sensors Letters · 2026

Protein sensing for wearable cardiac monitoring

02

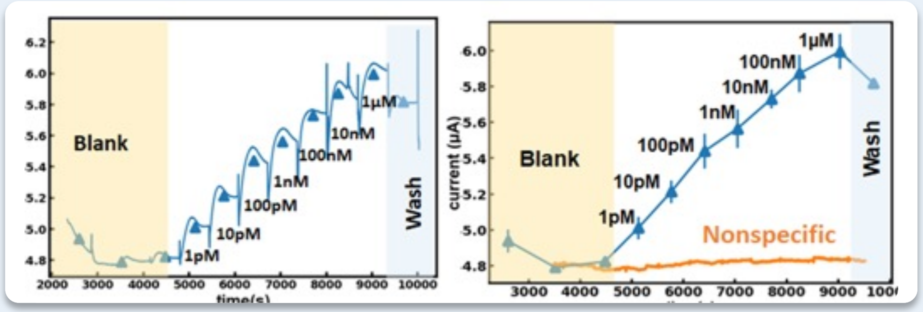
CORTISOL · STRESS HORMONE

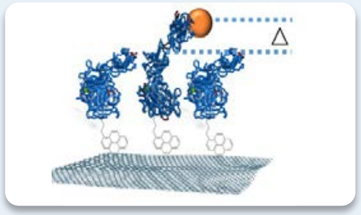
Collaboration with Melexis

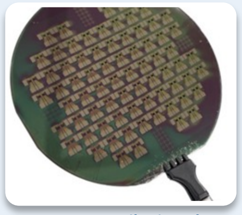
LIMIT OF DETECTION

0.1 ng/mL

in ISF







- SENSING INTERFACE
  Aptamer-on-graphene
- TRANSDUCTION
  Conformational change

A. Gilani et al. · Best Paper Award · IEEE Biosensors · 2026

BIO/CMOS INTERFACES LABORATORY

Bio/CMOS interfaces: from intensive care to neural dust

Prof. Sandro Carrara · co-designing bio-, nano- and CMOS sensing systems

CO-DESIGN PRINCIPLE

BIO	Molecular recognition and target specificity
NANO	Sensitive interfaces and functional materials
CMOS	Integrated readout, processing and autonomy

ONE INTERFACE · FIVE FORM FACTORS

Sensing moves closer to the patient

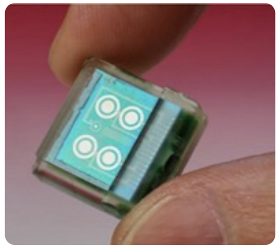
From an intensive-care platform and a portable anaesthetics pen to sub-cutaneous chips, a 40 µm CMOS biosensor and neural CMOS dust.

BEDSIDE → PORTABLE → IMPLANTABLE → MICRO-SCALE

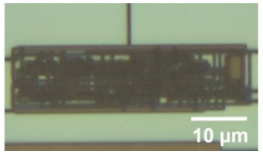
REPRESENTATIVE BIO/CMOS SYSTEMS

Portable platform for intensive care

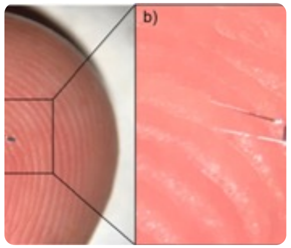
Anaesthetics in a portable pen



Sub-cutaneous monitoring chip



Smallest-ever CMOS biosensor · 40 µm



Neural CMOS dust

Miniaturization connects continuous biosensing with portable and implantable care.

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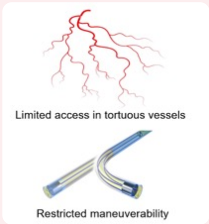
LABORATORY FOR ADVANCED FABRICATION TECHNOLOGIES

Untethered mechanically-active microrobots

Prof. Vivek Subramanian · Our work in LAFT

THE STATUS QUO

Endoscopy and catheters, with their associated challenges



MEDICAL NEED

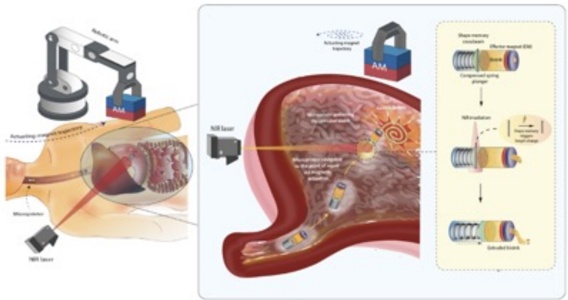
Safe, minimally invasive access to the biological highways

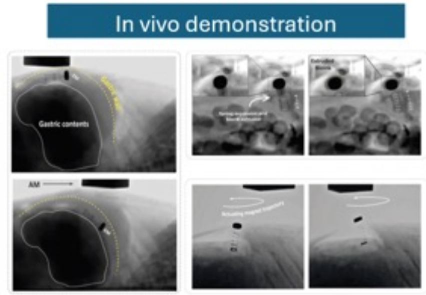
Endovascular system
Gastrointestinal system

OUR SOLUTION

Tether-less "dumb" microrobots with all intelligence and control provided from outside the body using magnetic fields and body-penetrating light

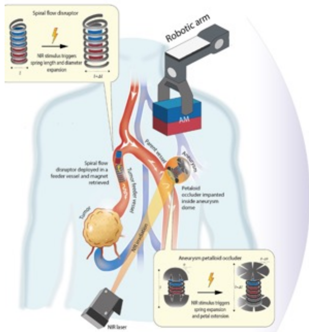
DEMO 1: A mm-scale 3D printer for repairing gastric ulcers





Successfully deployed in rabbits

DEMO 2: Two variants of aneurism-repair bots, successfully demonstrated ex-vivo and in-vitro



THE KEY

Synergistic development of materials, fabrication processes, device design, and control

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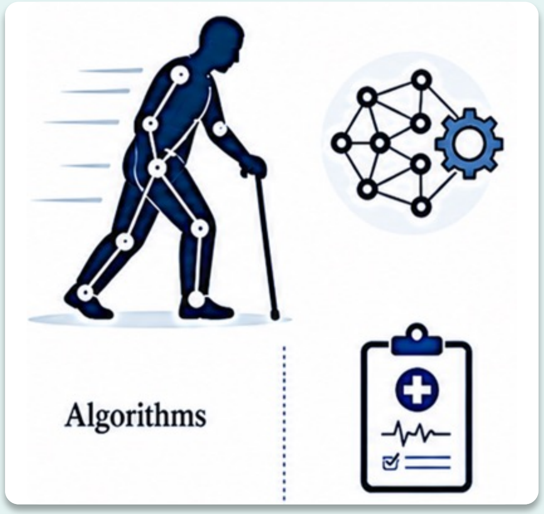
Motion analytics connects movement, sport and clinical decisions

Dr Anisoara Ionescu - human movement analysis, sport biomechanics and multimodal machine learning

01

HUMAN MOVEMENT ANALYSIS



ALGORITHMS → CLINICAL OUTCOMES

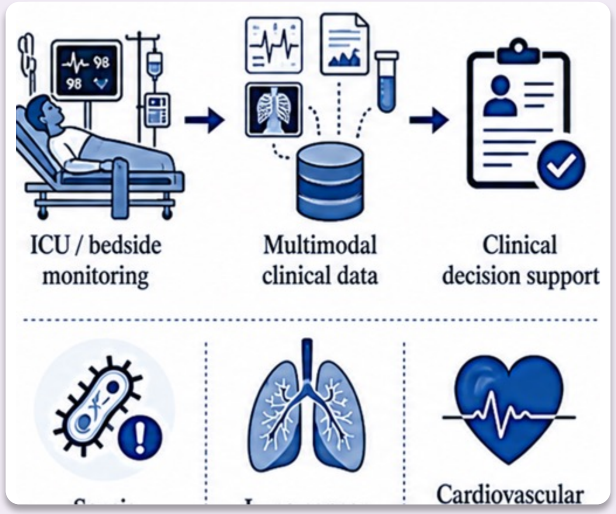
02

SPORT BIOMECHANICS

ICE-HOCKEY CONCUSSION ASSESSMENT

03

MULTIMODAL DATA ANALYTICS (ML)



BEDSIDE MONITORING → DATA → DECISION SUPPORT

Sepsis · Lung cancer · Cardiovascular diseases

LABORATORY OF MAGNETIC RESONANCE IMAGING SYSTEMS AND METHODS (SB/STI)

MRI sensing methods for advanced diagnostics

Prof. Dimitrios Karampinos - Development of novel MRI techniques · Development of quantitative MRI methods

DEVELOPMENT OF NOVEL MRI TECHNIQUES

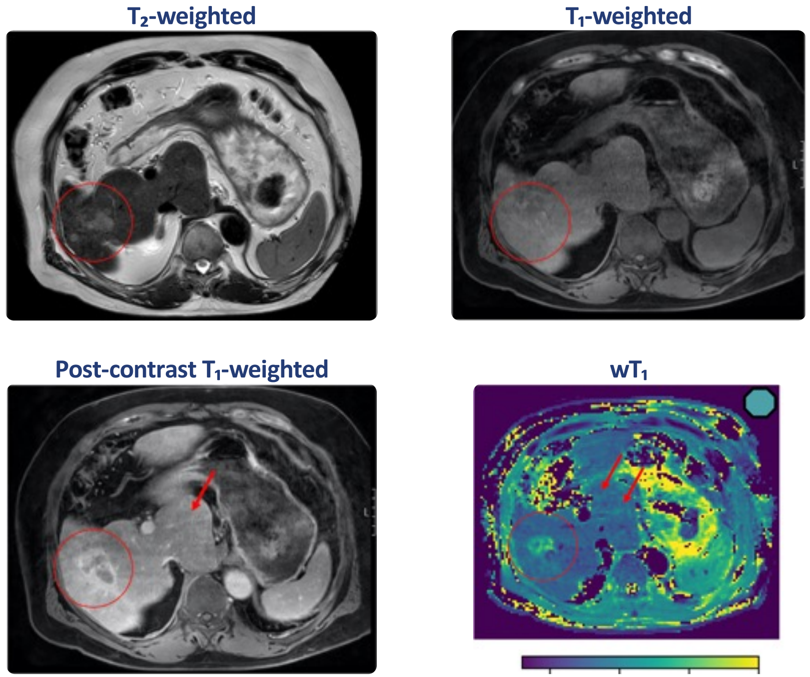
Data acquisition → Image reconstruction → Parametric mapping

Development of novel MRI techniques

- Pulse sequence designs
- Image reconstruction methods
- Signal modeling approaches

0.55 T & 3 T SCANNERS AT CHUV, LAUSANNE

DEVELOPMENT OF QUANTITATIVE MRI METHODS



Huaroc, ..., Karampinos, Exp Radiol Experimental 2026

EPFL

SIGNAL PROCESSING LABORATORY 5

Computational microstructure imaging by diffusion MRI

Prof. Jean-Philippe Thiran

THE CORE IDEA

Turn diffusion MRI signals into quantitative estimates of tissue microstructure.

01 — Tissue Models

02 — Numerical simulation

03 — Inverse problem

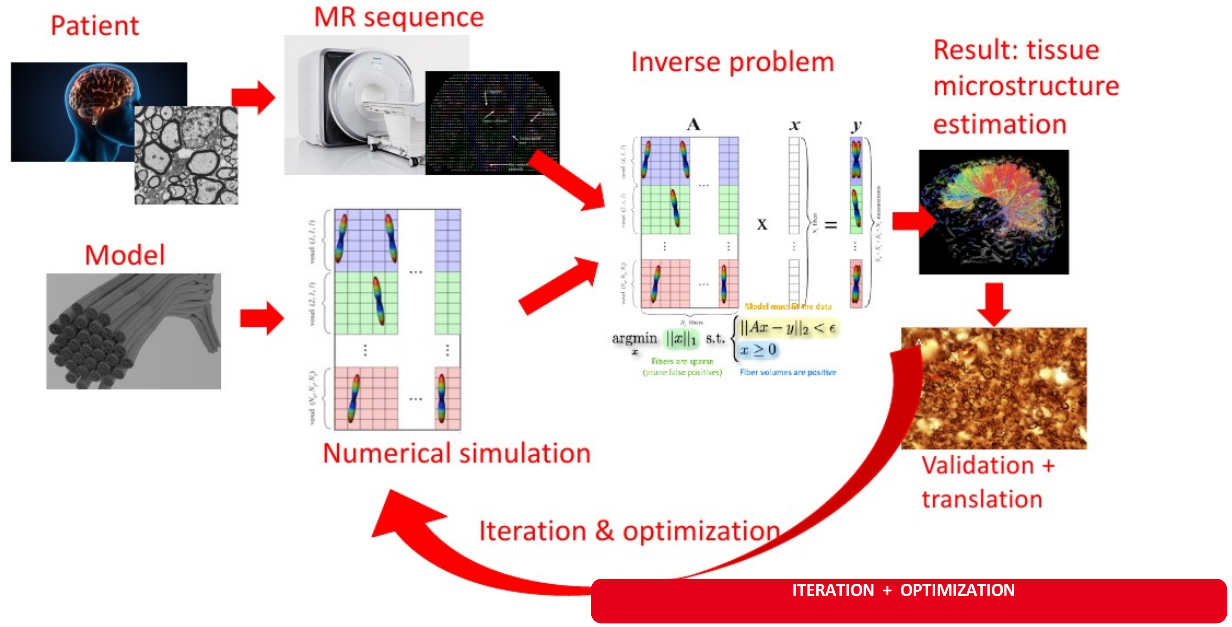
EXAMPLE

Axonal diameter mapping

Barakovic, 2021

ITERATIVE RECONSTRUCTION WORKFLOW

From acquisition and modelling to validation and translation



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SIGNAL PROCESSING LABORATORY 5

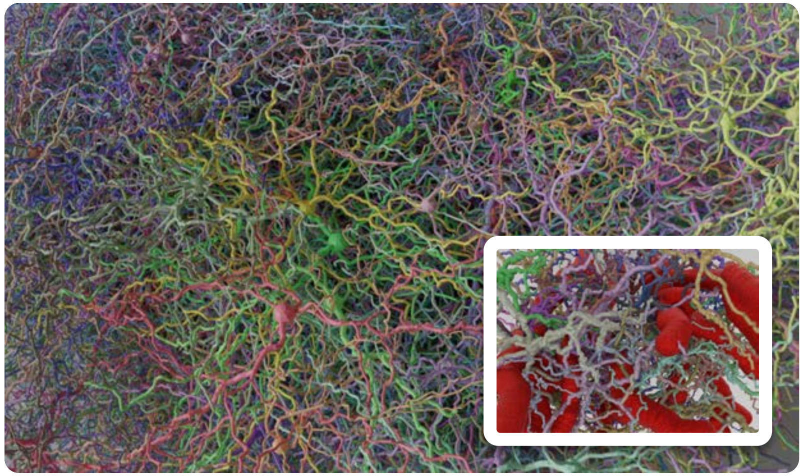
Computational microstructure imaging by diffusion MRI

Prof. Jean-Philippe Thiran

01 MODEL

Virtual tissue substrates

Substrate generator – CACTUS



Synthetic geometries for numerical simulation

02

VALIDATE

Simulation
↕
acquisition

TRANSLATION ECOSYSTEM — CIBM · CHUV · UNIL · HUG

SIGNAL PROCESSING LABORATORY 5

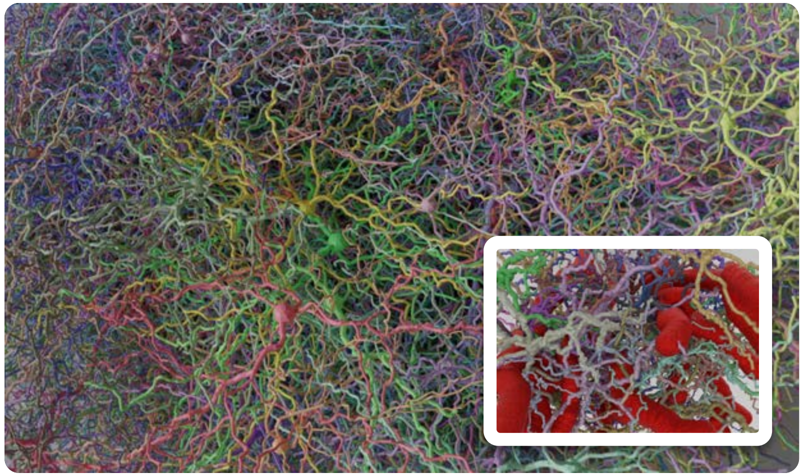
Computational microstructure imaging by diffusion MRI

Prof. Jean-Philippe Thiran

01 MODEL

Virtual tissue substrates

Substrate generator – CACTUS



Synthetic geometries for numerical simulation

02

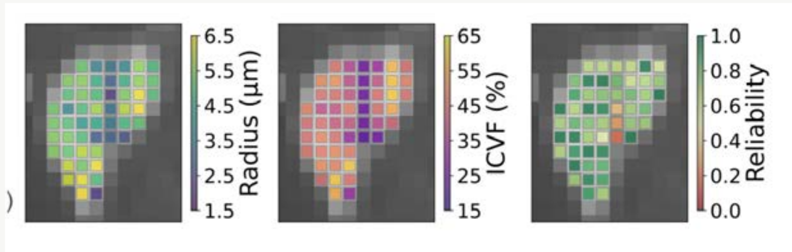
VALIDATE

Simulation ↕ acquisition

03 TRANSLATE

Quantitative oncology imaging

Microstructure imaging in oncology



QUANTITATIVE OUTPUTS

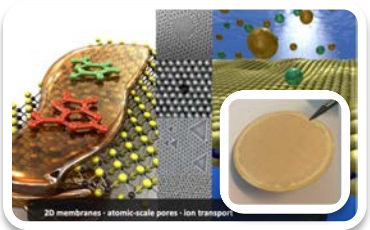
Radius (μm) · ICVF (%) · Reliability

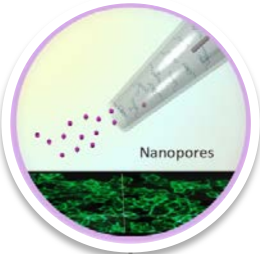
TRANSLATION ECOSYSTEM — CIBM · CHUV · UNIL · HUG

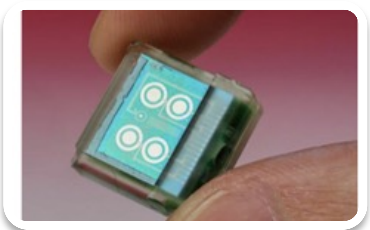
Engineering in Medicine - devices and sensors - from nano to macro

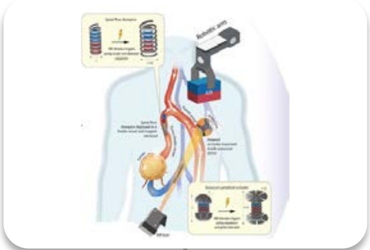
NANO → MACRO

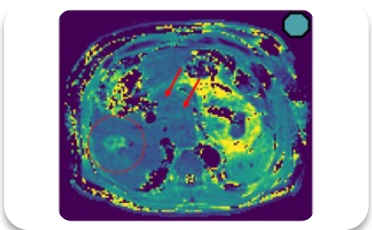
Molecular sensing, smart devices and clinical imaging are connected by scale.











01

Nano-engineering

- Nanotechnologies
- Nanophotonics

02

Molecular sensing

- Bio-chemistry
- Quantum sensors

03

Microsystems

- Microfluidics
- Nano-electronics
- Bioelectronics

04

Intelligent devices

- Micro-robots & Advanced manufacturing
- Motion sensors & signal processing

05

Clinical systems

- X-ray & MRI systems & methods

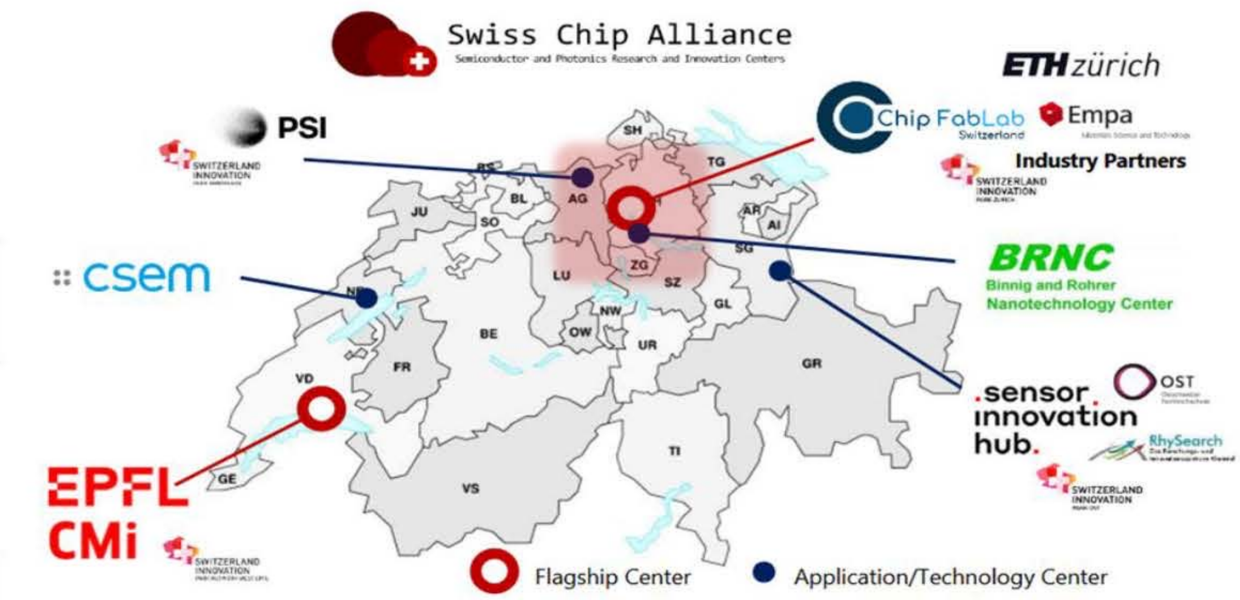
Engineering solutions to improve healthcare ….

… require

state-of-the-art nanofabrication facilities

with research & industrial capabilities

Swiss Chip FabLab



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