RL 3 – Photonics for health, food and cultural heritage

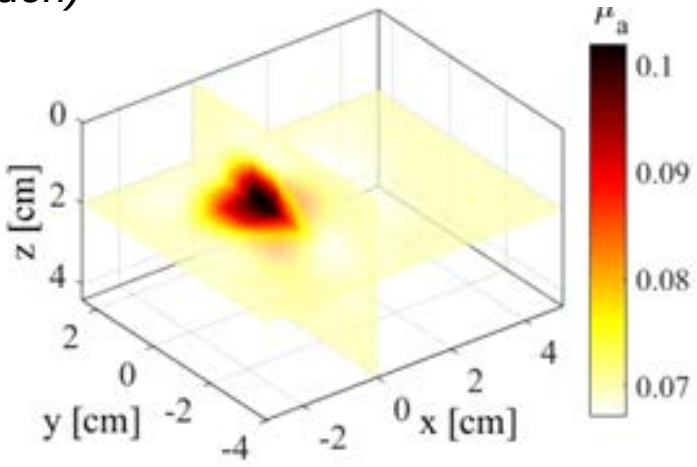
- Time-Domain Diffuse Optical Spectroscopy
- Time-Domain Diffuse Optics: Novel Technologies and Measurement Techniques
- Neurophotonics and functional near infrared spectroscopy
- Diffuse Optics for Clinics: Cancer detection and risk assessment
- Novel imaging techniques for biophysics
- Photonics for Cultural Heritage
- Nondestructive monitoring of food quality: Photonics for Food

https://www.fisi.polimi.it/en/teaching/students/thesis_available

Time-Domain Diffuse Optical Spectropscopy

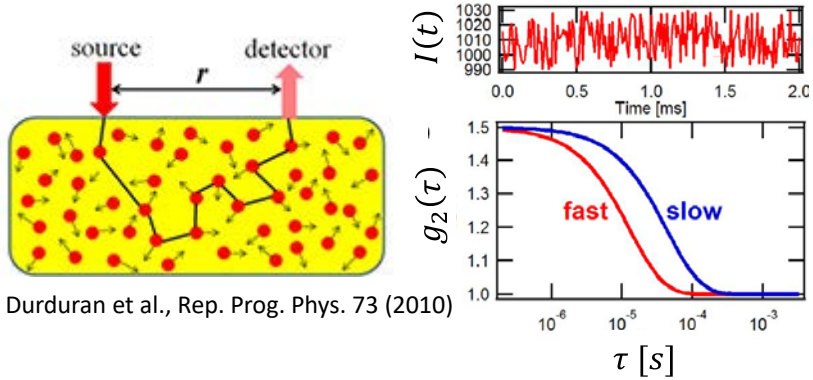
Applications – DOS lab

- ***Diffuse Tissue Spectroscopy***: investigate human tissues in vivo non-invasively to ascertain physiological and pathological status
- ***Diffuse Optical Tomography***: push 3D tomography in scattering media to the limits of depth and resolution *(collaboration with University College London)*



Techniques – DIRS lab

- ***Time-Domain Diffuse Raman***: a novel tool to probe biological tissues beyond the surface for clinical diagnostics *(collaboration with Rutherford Facility, Oxford)*
- ***Time-Domain Diffuse Correlation Spectroscopy***: new approaches, models, systems to measure blood flow in depth *(coll: ICFO, Barcelona)*



T Durduran et al., Rep. Prog. Phys. 73 (2010)

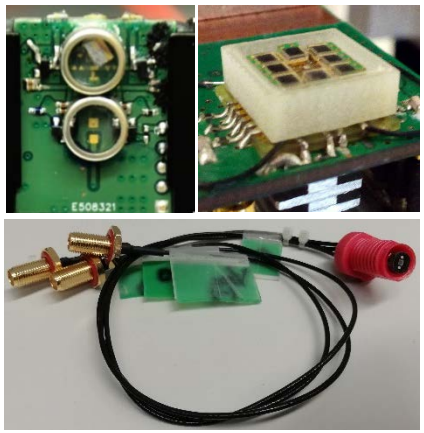
Contact: prof. Antonio Pifferi - antonio.pifferi@polimi.it

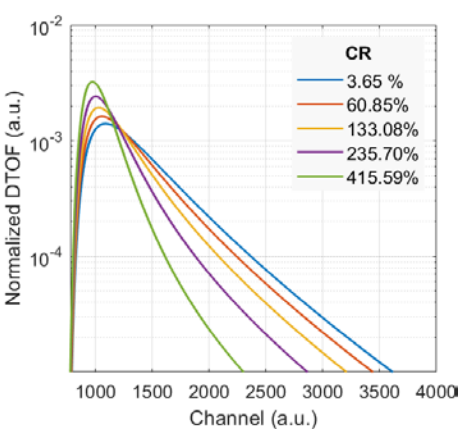
Time-Domain Diffuse Optics:
Novel Technologies and Measurement Techniques

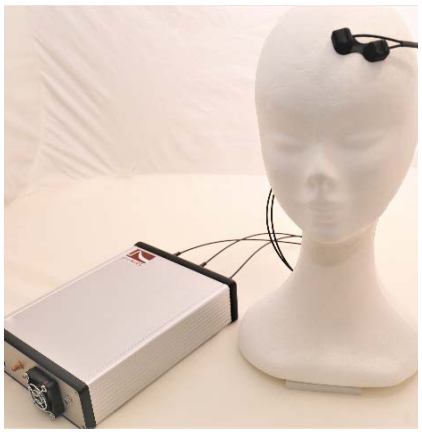
- ***Photonic Components***:
  design/validation of cutting-edge components (time-gated and/or large-area single-photon detectors, miniaturized picosecond laser sources) for next generation systems

- ***Photonic Systems***:
  design/validation of new photonics systems: i) miniaturized devices for clinical applications and smart personal appliances, ii) multichannel/tomographic systems for real-time imaging and spectroscopy

- ***Measurement Techniques***:
  push the technique to its ultimate performances (extreme depth penetration, real-time measurements) with novel approaches/techniques: i) single-photon detection beyond traditional pile-up limitation, ii) null source-detector separation, iii) fast-gated detection

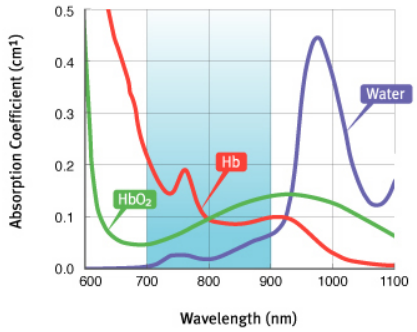


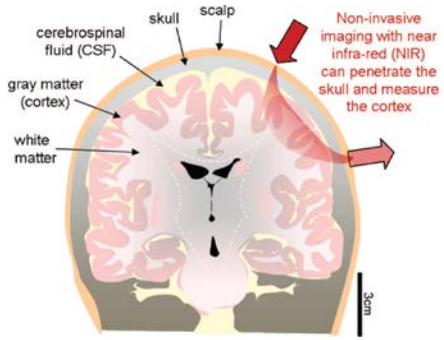


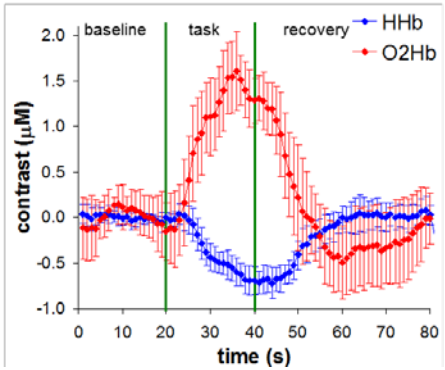


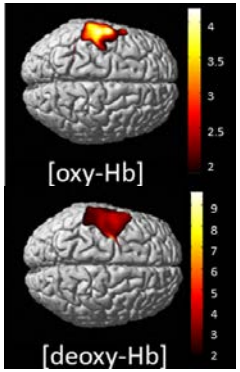
Contacts: prof. Alberto Dalla Mora – alberto.dallamora@polimi.it
dr. Laura Di Sieno – laura.disieno@polimi.it

Neurophotonics and functional near infrared spectroscopy
Photonics for Health





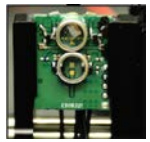




- ***Physical modelling***: Development and validation of analytical and numerical models for light propagation in complex diffusive media (e.g. human head)
- ***Instrumentation***: Design, development and characterization of advanced photonic components and systems for detection of weak and fast optical signals. From laboratory systems to bedside medical devices.
- ***Clinical applications***: Noninvasive monitoring / imaging of oxidative metabolism and cerebral hemodynamics in volunteers and patients. In collaboration with clinical research groups in Neurosciences, Pediatrics, Rehabilitation, Psychology and Sport Medicine.








Contacts: prof. Alessandro Torricelli – alessandro.torricelli@polimi.it
prof. Davide Contini – davide.contini@polimi.it

Diffuse Optics for Clinics

Optical imaging of the breast: Cancer detection, therapy monitoring, and risk assessment

WHAT

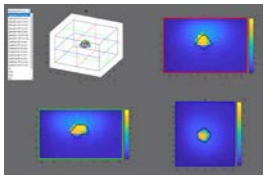
Time domain multiwavelength diffuse optical imaging to estimate **tissue composition and structure** for:

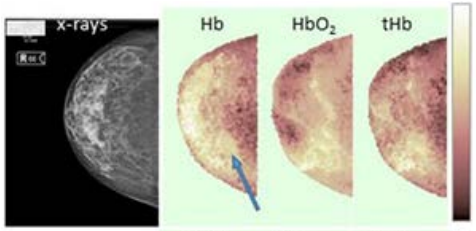
- Improved discrimination between malignant and benign breast lesions
- Assessment of cancer risk related to breast density
- Monitoring and prediction of pathologic outcome of neoadjuvant chemotherapy

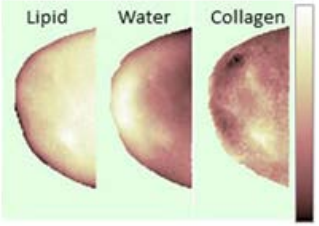
HOW

Research activity and innovative developments in:

- Approaches to diffuse optics for *in vivo* applications
- Device development
- Tomographic data reconstruction
- Multiparametric data analysis
- Clinical validation







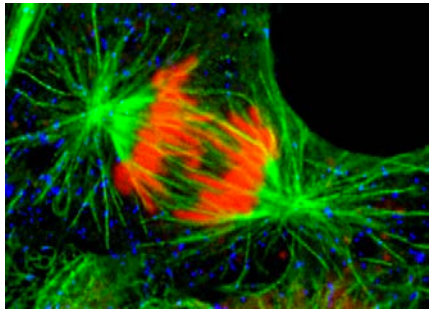
H2020 project
www.solus-project.eu

SOLUS
SMART OPTICAL AND ULTRASOUND DIAGNOSTICS OF BREAST CANCER

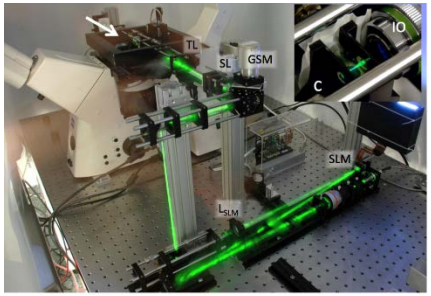
Contact: prof. Paola Taroni – paola.taroni@polimi.it

Novel imaging techniques for biophysics

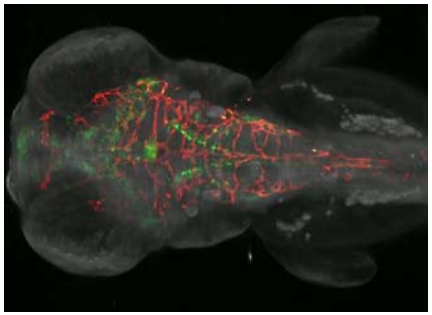
Imaging and **spectroscopy** are fundamental tools to study the **biophysics of cells** and living organisms.
The thesis aim at developing novel photonics techniques for life science.



- **Novel Microscope configurations**: construct advanced optical systems (light sheet fluorescence microscopes and structured illumination)



- **Computational imaging**: combine multidimensional imaging and time-resolved fluorescence spectroscopy.



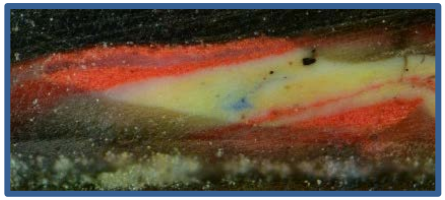
- **Applications**: study the biophysics of cells , plants and organisms (calcium transients, photosynthesis, genetics)

Contact: prof. Andrea Bassi – andrea1.bassi@polimi prof. Cosimo D'Andrea – cosimo.dandrea@polimi.it dr. Andrea Farina – andrea.farina@polimi.it

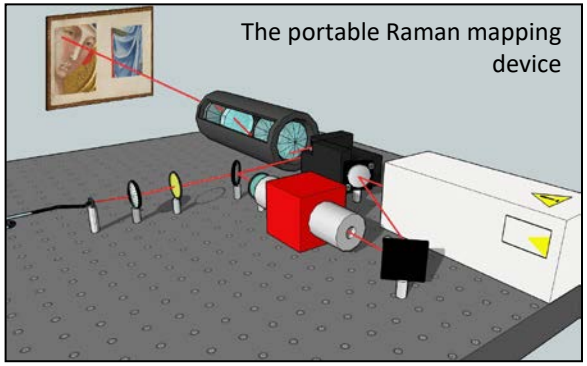
Photonics for Cultural Heritage

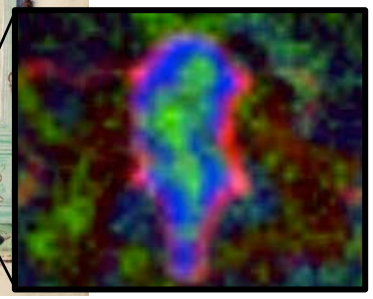
- ***Engineering***: Development of portable spectroscopy and imaging devices for in-situ studies of artworks
- ***Material science***: Photo-physical characterization of artistic pigments through complementary spectroscopy techniques (PL, XRF, Raman,…)
- **Imaging and microscopy**: Analysis of case-studies (paintings and micro-samples) through photonics-based methods

Study of altered cadmium yellow (CdS) paints in Picasso's *Femme*



Stratigraphic micro-sample

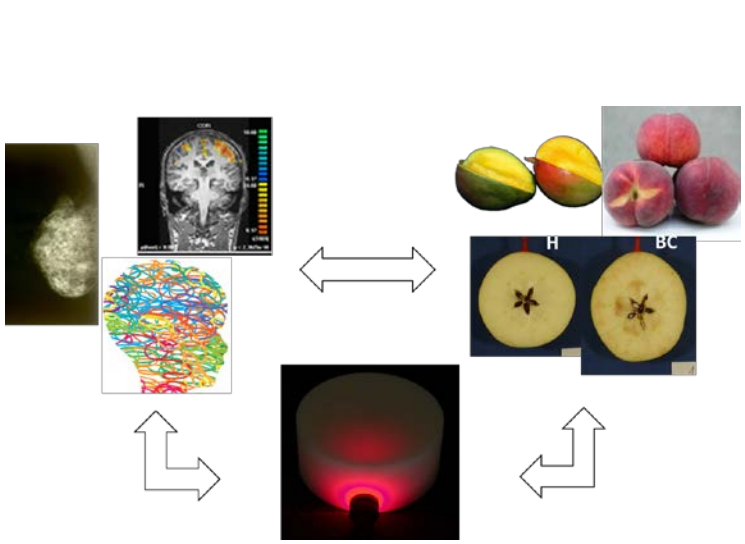


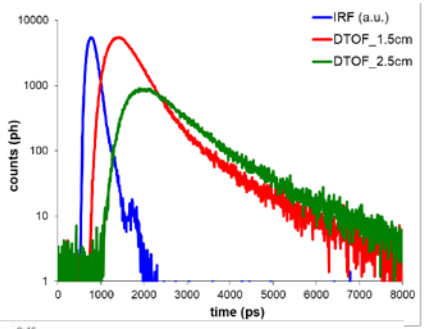


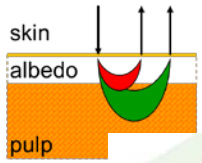
Discovery of the hidden coat-of-arm in a Middle Age illuminated manuscript

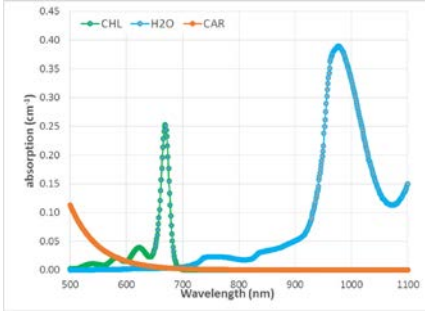
Contact: prof Daniela Comelli – daniela.comelli@polimi.it
prof. Gianluca Valentini – gianluca.valentini@polimi.it

Nondestructive monitoring of food quality
Photonics for Food









- ***Physical modelling***: Development and validation of analytical and numerical models for light propagation in complex diffusive media (e.g. fruit and vegetables)
- ***Instrumentation***: Design, development and characterization of advanced photonic systems for nondestructive characterization of bulk optical properties. From laboratory systems to on line grading tools.
- ***Field applications***: Nondestructive monitoring of maturity index and internal disorders in fruits. In collaboration with horticultural research groups (e.g. CREA, Laimburg).

Contacts: prof. Alessandro Torricelli – alessandro.torricelli@polimi.it
dr. Lorenzo Spinelli – lorenzo.spinelli@polimi.it