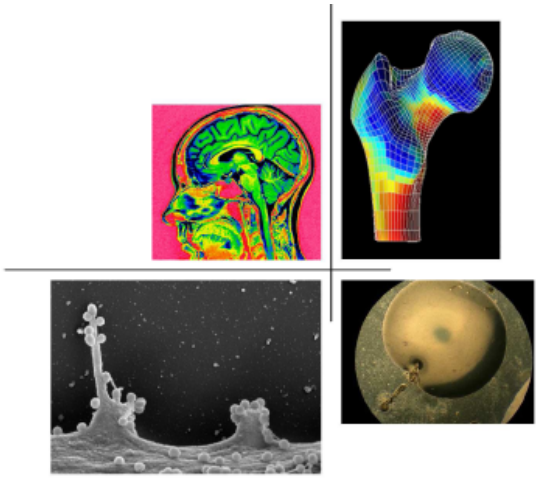
UNIVERSITÉ PARIS DESCARTES

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

BioMedical Engineering
Master's Degree Program

bme Paris
BioMedical Engineering
MASTER PROGRAM



BioImaging Track (BIM)

Track chairs:

- E. Angelini , PhD (Telecom ParisTech)
- F. Cloppet , PhD (Univ. Paris Descartes)
- C. Oppenheim , MD (Univ. Paris Descartes)

http://www.bme-paris.org

IDV
IMAGERIE DU VIVANT

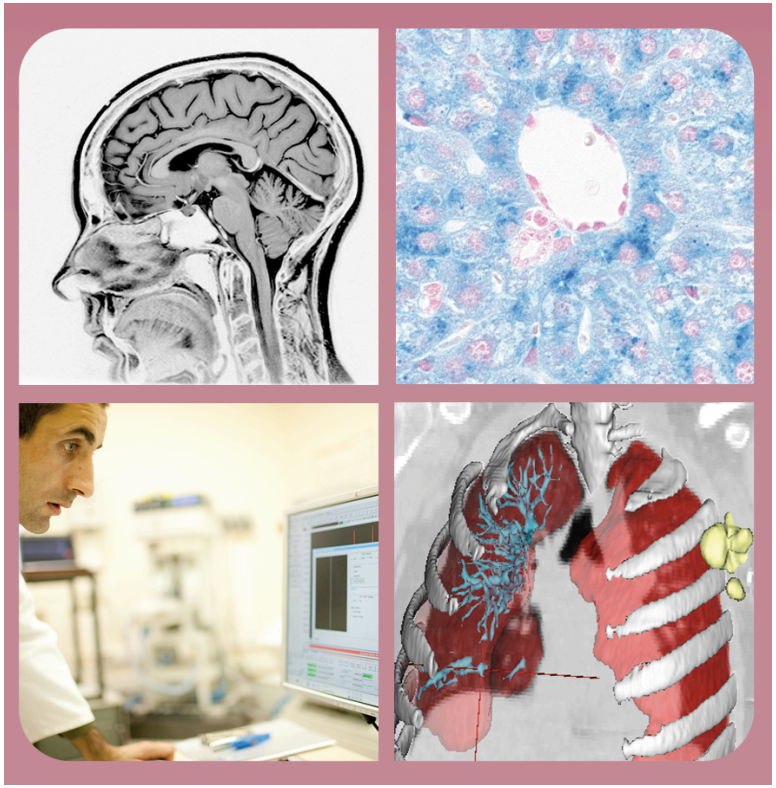
bme Paris
BioMedical Engineering
MASTER PROGRAM

BioImaging Track

Catherine Oppenheim
Medicine
Université Paris Descartes

Florence Cloppet
Computer Science
Université Paris Descartes

Elsa Angelini
Computer Science
Telecom ParisTech



Bioimaging is an exciting **field** at the interface between Mathematics, computer science, chemistry, physics, life science, biology and medicine.

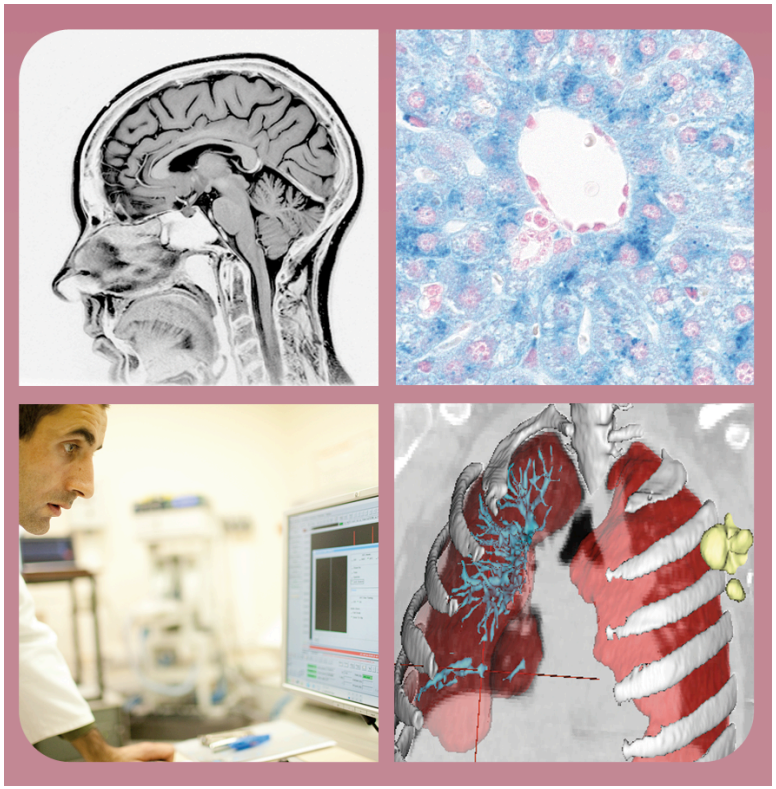
The main **goal** of Bioimaging is to improve human health using imaging modalities to advance diagnosis, treatment and prevention of human disease.

BioImaging Track

Catherine Oppenheim
Medicine
Université Paris Descartes

Florence Cloppet
Computer Science
Université Paris Descartes

Elsa Angelini
Computer Science
Telecom ParisTech



▶ SUB-TRACK Imaging from Molecule to Human (IMH)

IDV IMAGERIE DU VIVANT

UNIVERSITÉ PARIS DESCARTES

▶ IMH@bme-paris.org

▶ SUB-TRACK Imaging Modalities and Processing (IMP)

TELECOM ParisTech

UNIVERSITÉ PARIS DESCARTES

▶ IMP@bme-paris.org

université PARIS DIDEROT PARIS 7

ENSTA ParisTech

MINES ParisTech

INSTITUT d'OPTIQUE GRADUATE SCHOOL

Chimie Paris ParisTech

BioImaging Track

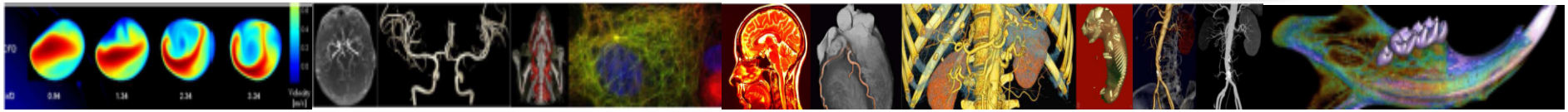
- Complementary skills from:
  - University Paris Descartes,
  - Paris Diderot
  - Engineering schools of ParisTech

- BIM program:
  - 15 courses (UE) at the M2 level.
  - Co-organized by faculty members experts in the field.

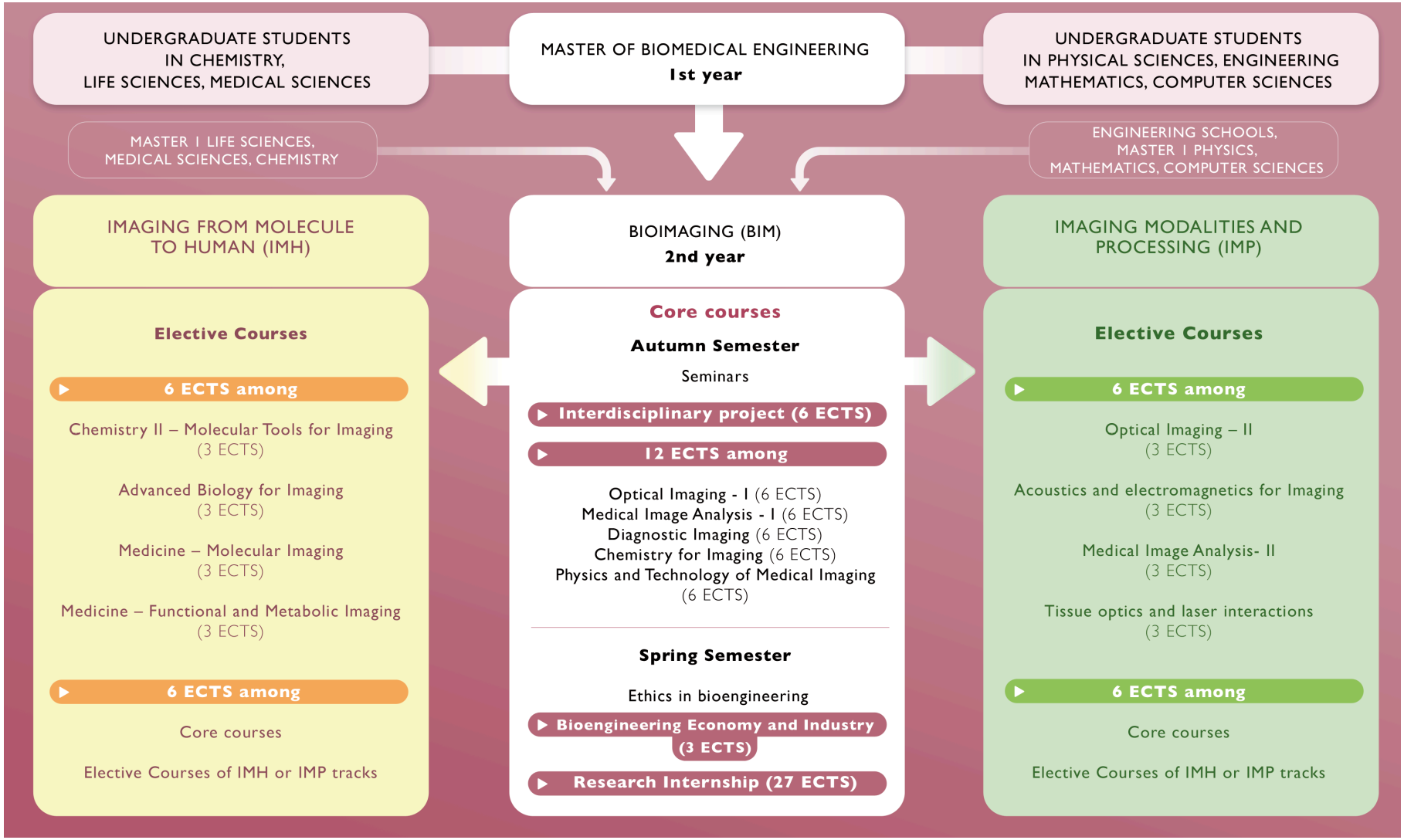
Basic sciences: mathematics, physics, chemistry

Applied mathematics: signal& image processing, numerical analysis.

Biology and Medicine: diagnostic tools, innovative screening, contrast agents, biomarkers, image-based modeling



BioImaging Track Program



BIM Research Labs

- **Image Processing Labs**:
  - **Telecom ParisTech**: Medical image processing group
  - **Paris Descartes** – UFR Mathematics-Computer Sciences
  - **Mines ParisTech**: Biological image processing
  - Arts et Métier ParisTech: musculo-skeletic imaging
- **Radiology Labs:**
  - **Hospitals** Ste Anne, HEGP, Lariboisière,….
  - **PARCC** Paris Cardiovascular Center of Research
- **Optical Imaging Labs:**
  - **Animal imaging platform**: Microscopy, Spectroscopy via Electronic Paramagnetic Resonance,
  - **Institut d'Optique** Graduate School ParisTech
  - **ENSTA ParisTech**: Laser-tissue interactions
  - **ESPCI**: novel elastography ultrasound imaging
- **Chemistry Labs:**
  - **Chimie ParisTech:** bio photonics, scintillators, luminescence nano-chemistry
  - **University Paris Descartes:** molecular imaging

ParisTech

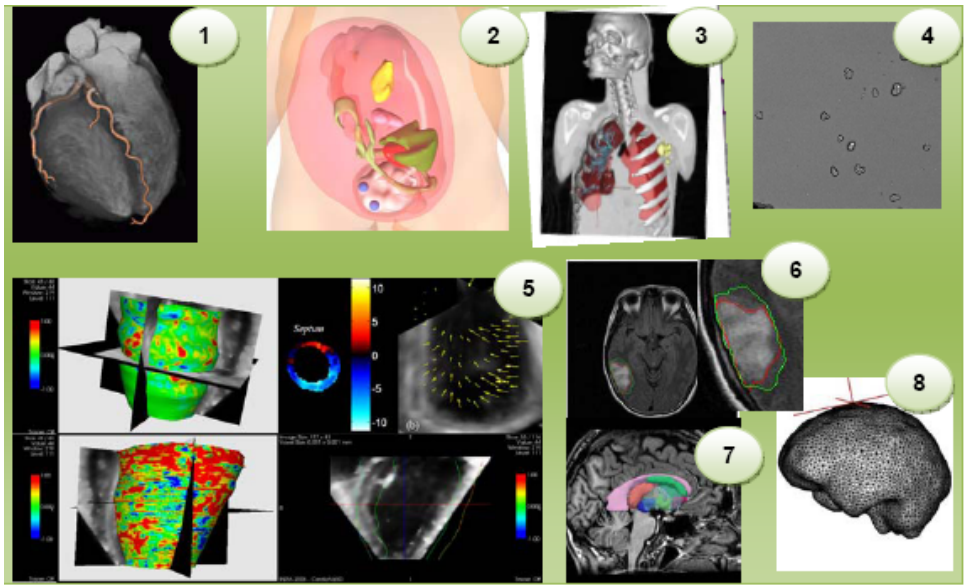
8 schools involved in BioImaging

Telecom ParisTech

Department of Signal and Image Processing

- **Faculty :**
  - Elsa Angelini (elsa.angelini@telecom-paristech.fr)
  - Isabelle Bloch (isabelle.bloch@telecom-paristech.fr)

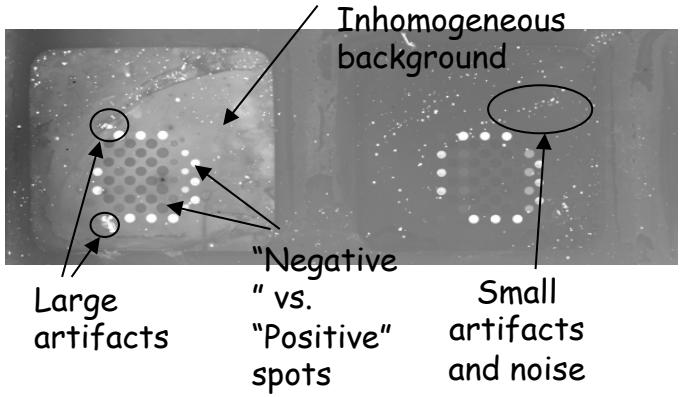
- **Specialty :** medical image processing (denoising, segmentation, registration, anatomical modeling,..)
- **Imaging modalities** : MRI, CT, PET-SPECT, ultrasound, retinal imaging, microscopy
- **Clinical applications**: brain, cardiac, thorax, obstetric, mammography, optical imaging
- **Academic collaborators :** CNRS, INSERM, INRIA, Institut Pasteur**,** several hospitals, Columbia University
- **Industrial partners :** Philips Healthcare, GE Healthcare, Siemens Corporate Research, Dosisoft, Echosens , …

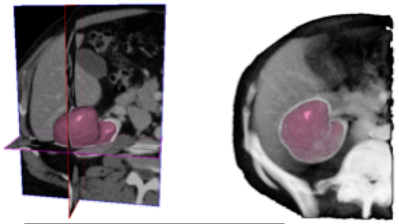


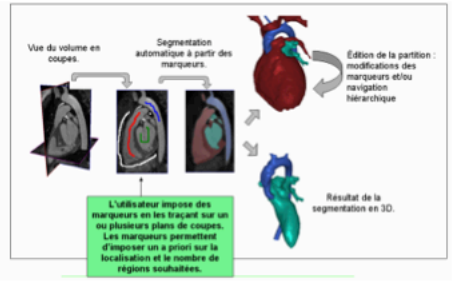
Mines ParisTech

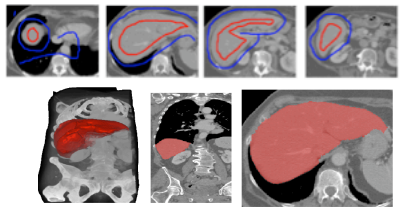
Centre de Morphologie Mathématique

- **Faculty :**
  - Etienne Desenciere (etienne.decenciere@ensmp.fr)
- **Specialty :** biomedical image processing (interactive 3D segmentation, quantification, dynamic analysis), mathematical morphology
- **Imaging modalities:** DNA and cells microarrays, MRI, CT, retinal imaging, microscopy
- **Clinical applications**: quantitative cytology and histology, angiogenesis quantification, cancerology
- **Academic collaborators :** Institut Gustave Roussy, Institut Curie
- **Industrial partners :** GE Healthcare, sanofi, l'Oréal





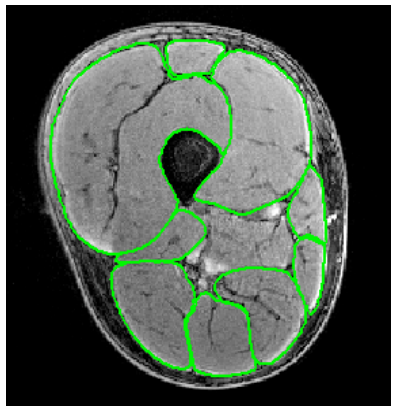


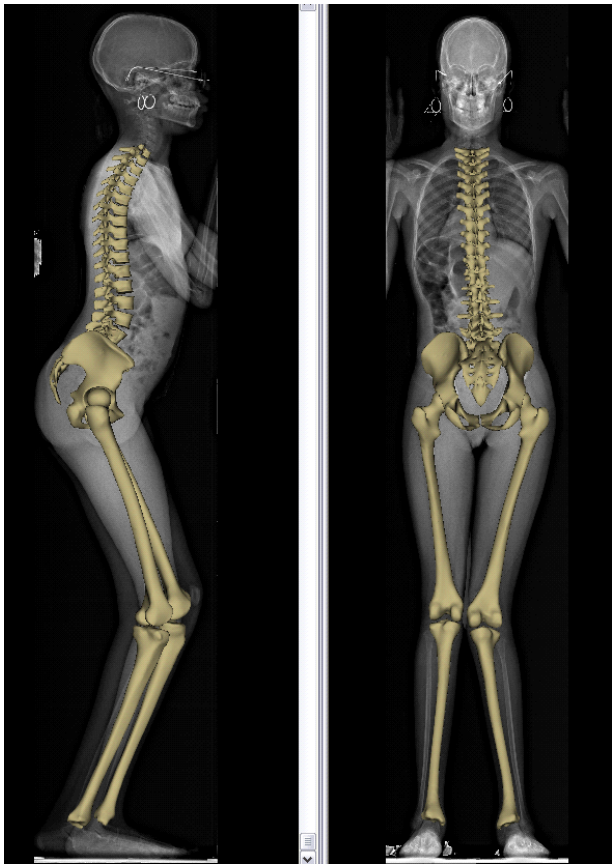


Arts et Métiers ParisTech

Laboratoire de Biomécanique

- **Faculty:**
  - Sébastien Laporte (sebastien.laporte@paris.ensam.fr)
  - Wafa Skalli (wafa.skalli@paris.ensam.fr)
- **Specialty :** anatomical modeling
- **Imaging modalities:** X-ray, MRI, musculo-skletic imaging
- **Clinical applications**: numerical simulations, prosthesis design, surgery planing
- **Academic collaborators :** University of Montreal, several hospitals
- **Industrial partners :** EOS Imaging, Renault,…

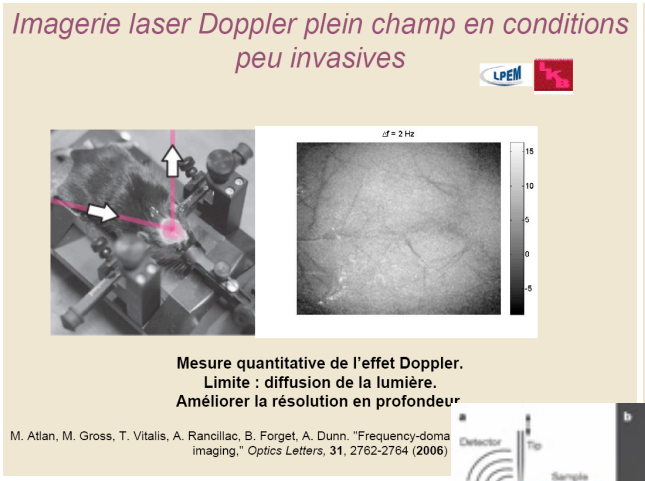


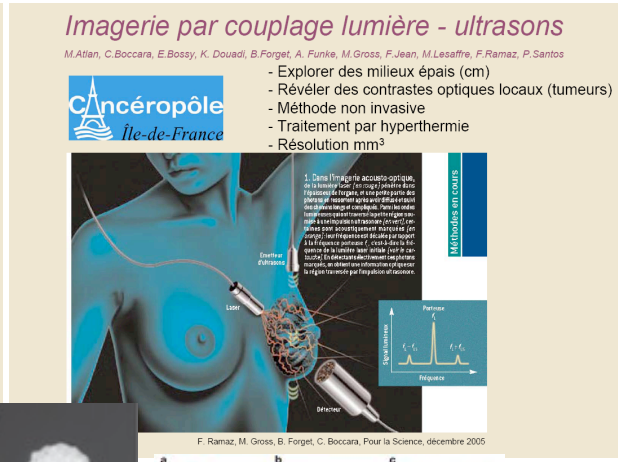


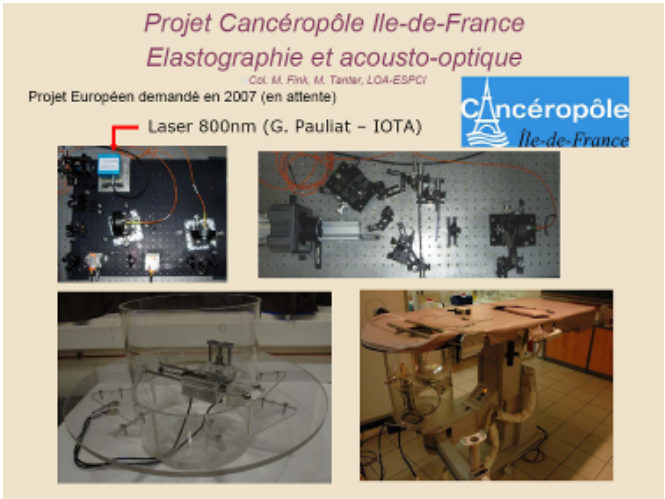
ESPCI ParisTech

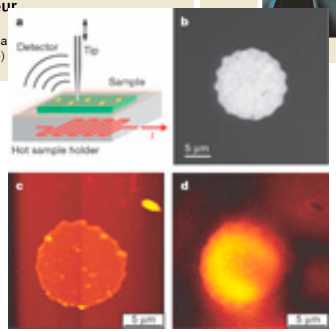
Institut Langevin

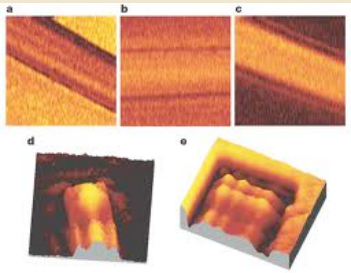
- **Faculty:**
  - Emmanuel Bossy (emmanuel.bossy@espci.fr)
  - Remi Carminati (remi.carminati@espci.fr)
- **Specialty :** imaging of complex media, imaging devices, nanophysics, nanostructures, nanomaterials
- **Imaging modalities:** laser, ultrasound, photo-acoustic, elastography, holography, adpative optics, thermal imaging
- **Clinical applications**: cell imaging, biology, vessels, tissue characterization,
- **Academic collaborators :** Institut Langevin, University P5, Institut Pasteur
- **Industrial partners :** l'Oréal

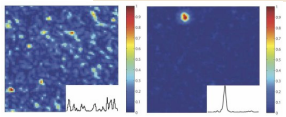










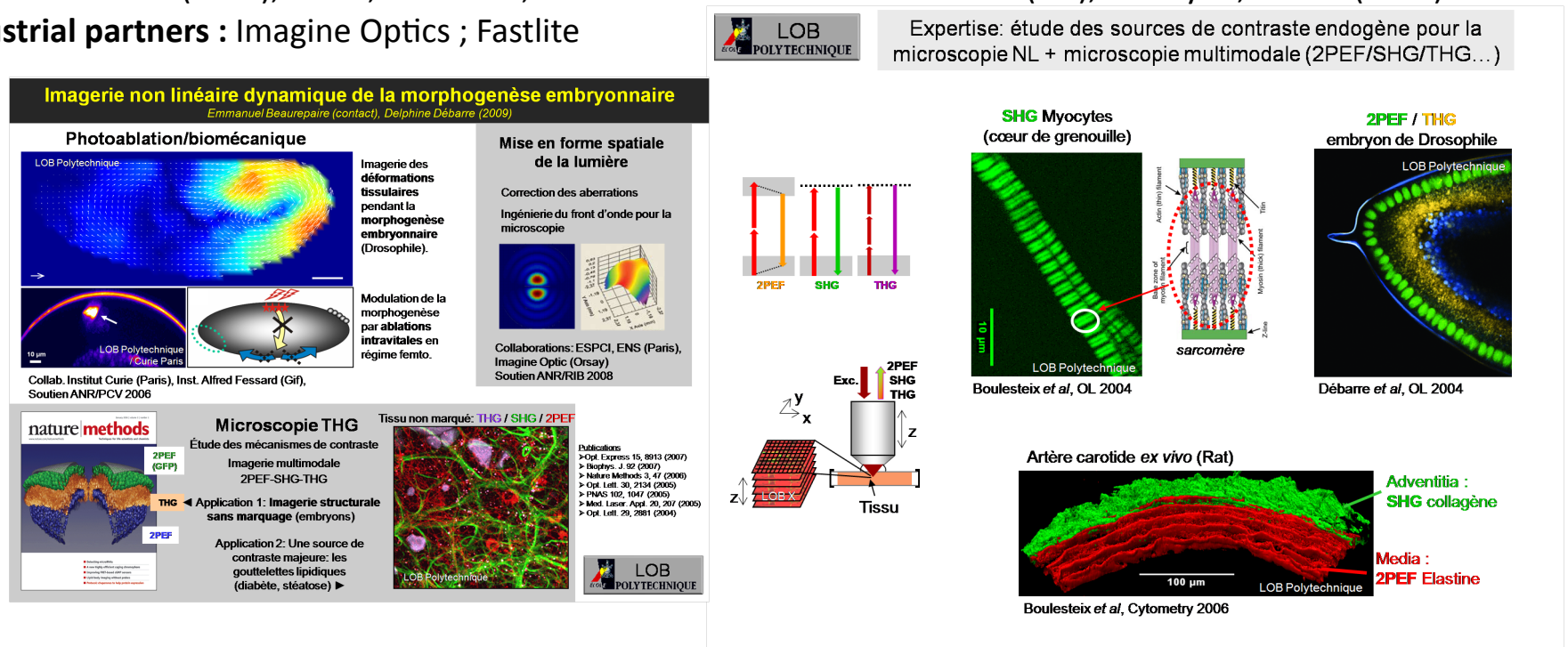


Thermal radiation scanning tunnelling microscopy

Polytechnique

Laboratoire d'Optique et Biosciences (LOB)

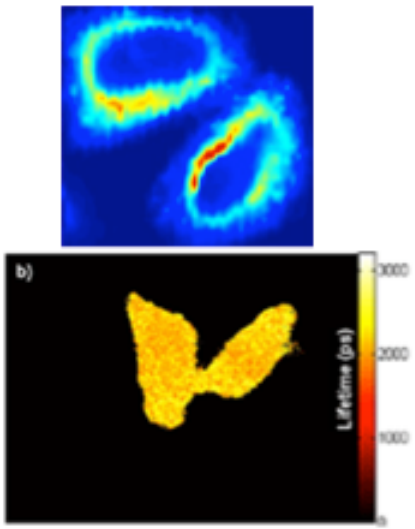
- **Faculty:**
  - Emmanuel Beaurepaire (Emmanuel.Beaurepaire@polytechnique.fr)
- **Specialty :** multiphotonic microscopy, design of imaging devices
- **Imaging modalities:** laser, SHG, THG, spectroscopy
- Biological applications: nanoparticuls tracking, embryonic development, extracellular matrix imaging
- **Academic collaborators DGA, INRIA,** Institut Curie (Paris), Hospitals Bichat-Lariboisière (Paris), Centre rech. Cardiovasculaire (Paris), ESPCI, ENS-Paris, Institut Neurobiol. Alfred Fessard (Gif), ENS Lyon, UPMC (Paris)
- **Industrial partners :** Imagine Optics ; Fastlite



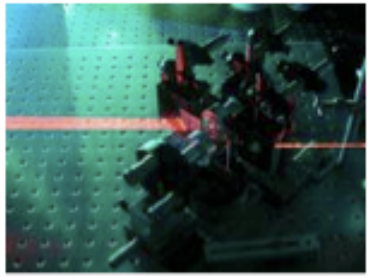
Institut d'Optique

Group Lasers & Biophotonics

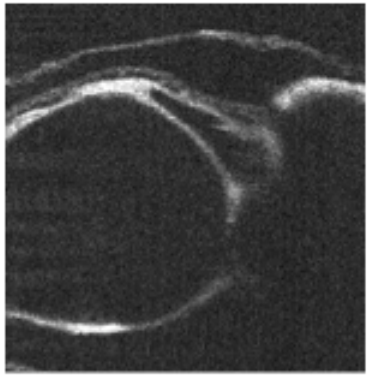
- **Faculty:**
  - Arnaud Dubois (arnaud.dubois@institutoptique.fr)
- **Specialty :** fluorescence microscopy, OCT, biochips, device design
- **Imaging modalities:** laser, microscopy,
- **Bio-Clinical applications**: imaging in diffusing media, retinal imaging, prostate, genetic diagnosis
- **Academic collaborators :** CNRS, INSERM, LPPM et Centre de Photonique Biomédicale (UPSud), IEF (Orsay), CGM (Gif/Yvette) LOA (ENSTA), Hotel Dieu (Paris), CEA LETI (Grenoble), CHU Bordeaux, ESPCI……
- **Industrial partners :** Genoptics, Imagine Eyes, Amplitude Systèmes,



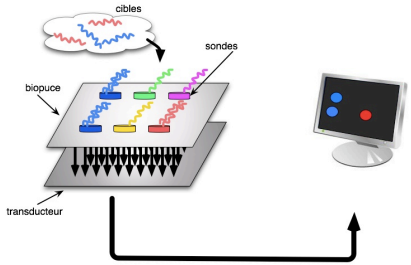
Total Internal Reflexion Fluorescence Lifetime Imaging Microscopy

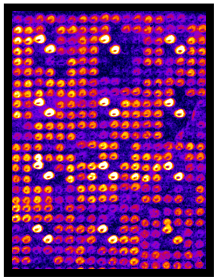


Multifocal Two-Photon Fluorescence Lifetime Microscopy



Full Field Optical Coherence Tomography

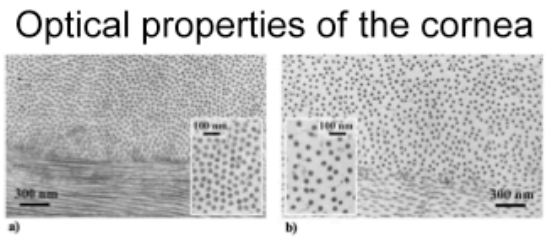




ENSTA ParisTech

Laboratoire d'Optique Appliquée (Palaiseau)

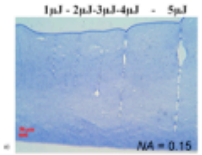
- **Faculty:**
  - Karsten Plamann (karsten.plamann@ensta-paristech.fr)
- **Specialty :** laser eye surgery, OCT interventional imaging
- **Imaging modalities:** laser, microscopy,
- **Bio-Clinical applications**: imaging in diffusing media, retinal imaging, prostate, genetic diagnosis
- **Academic collaborators :** Laboratoire Biotechnologie et Œil (hôpital Hôtel Dieu / université Paris V), Banque Française des Yeux, Institut d'Optique *Graduate School*, École Polytechnique, University Paris Descartes
- **Industrial partners :** Imagine Eyes, Amplitude Systèmes



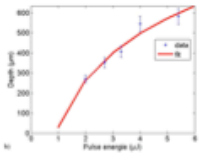
transparent cornea characterized by a short range order

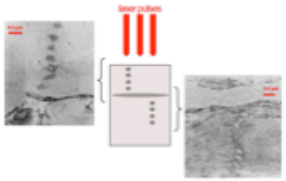
oedematous cornea in which the regular arrangement of the fibres is perturbed


Human cornea obtained from the *Banque Française des Yeux* (French Eye Bank)

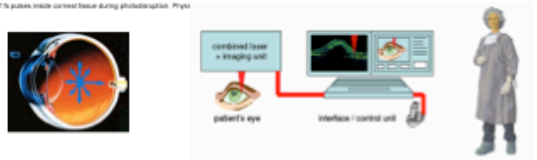


Penetration depths for different pulse energies


Penetration depths vs. pulse energy


TEM photographs of a periodic structure below and above the lamellar plane in which the incision was performed

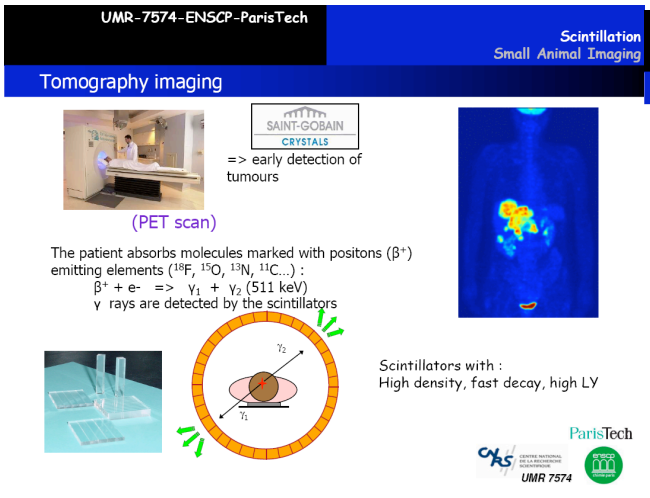

Focusing-defocusing cycles undergone by the intense core of a laser beam.

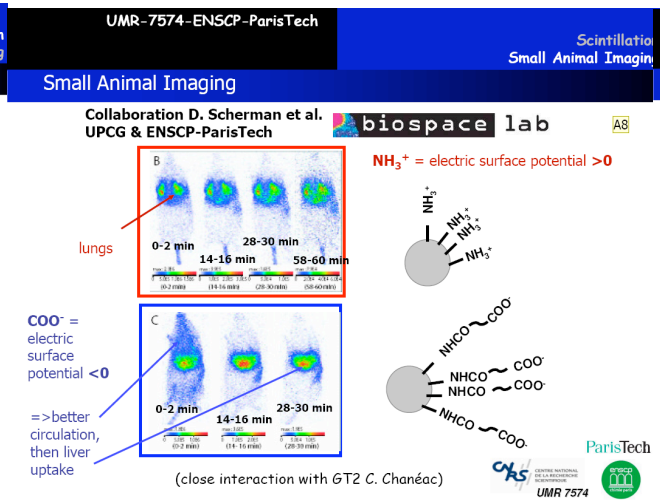


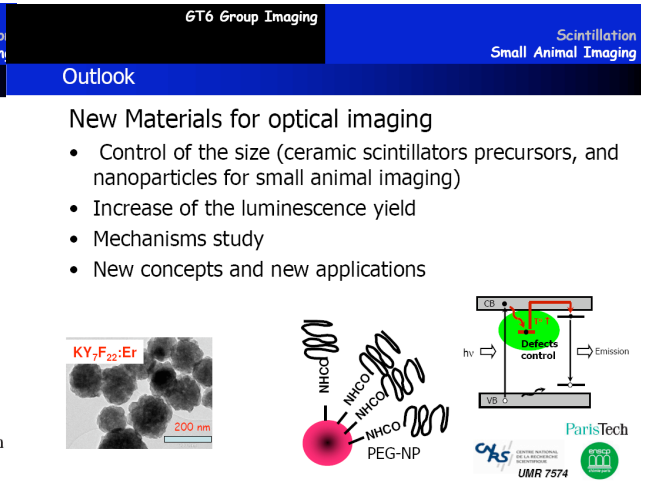
Chimie ParisTech

Laboratoire de Chimie de la Matière Condensée de Paris

- **Faculty:**
  - Bruno Viana (bruno-viana@enscp.fr)
- **Specialty :** chemical agents for imaging, biophotonics, scintillation material, luminiscence material, nanoparticles,
- **Imaging modalities:** PET, SPECT,
- **Bio-Clinical applications:** cancer imaging, small animal imaging
- **Academic collaborators :** CNRS, Paris 6, Collège de France
- **Industrial partners:** Saint-Gobain, Biospace



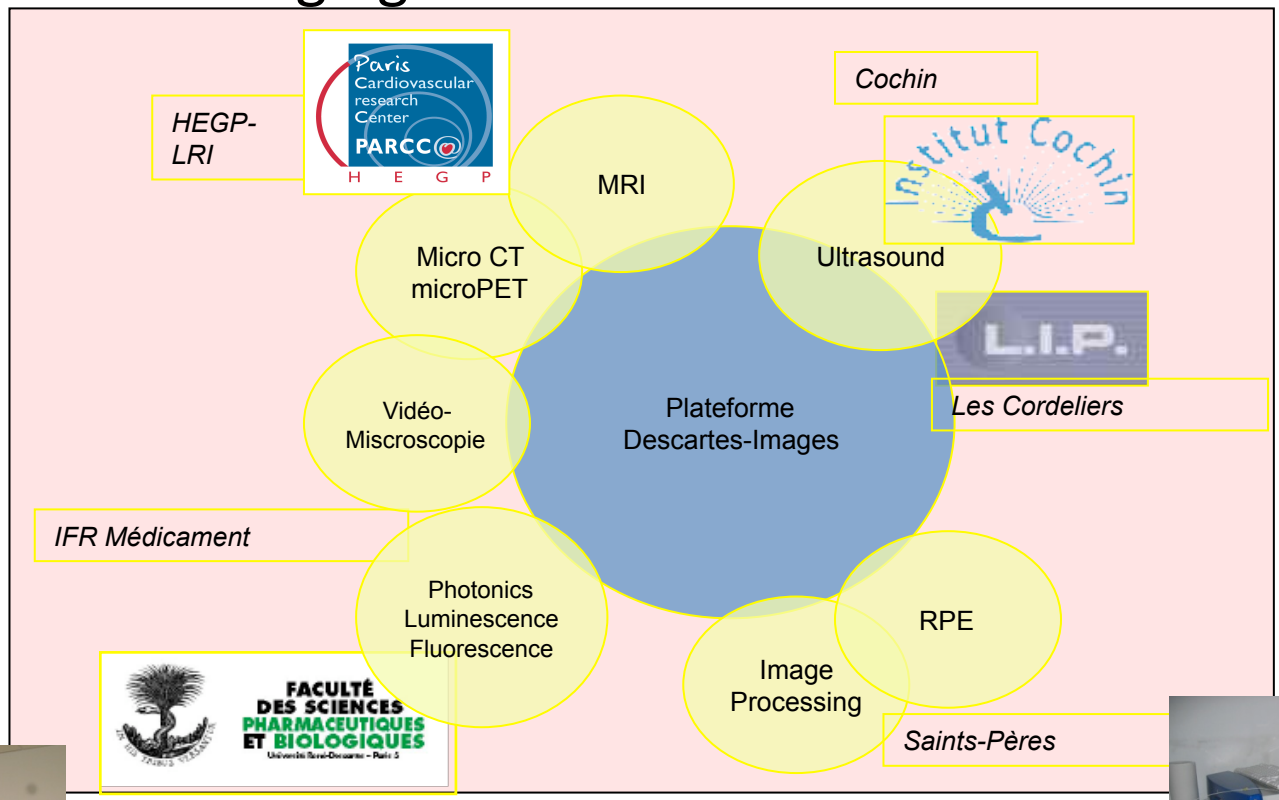




University Paris Descartes

Faculty:
Charles André Cuenod (ca@cuenod.net)

Imaging Platforms and Resources



Région Ile de France

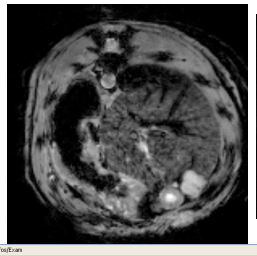
UNIVERSITÉ PARIS DESCARTES

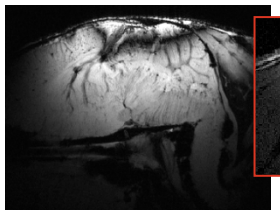
University Paris Descartes

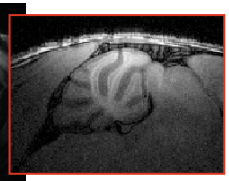
Faculty:

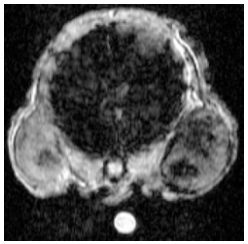
- Charles André Cuenod (ca@cuenod.net)
- Olivier Clément (olivier.clement@inserm.fr)

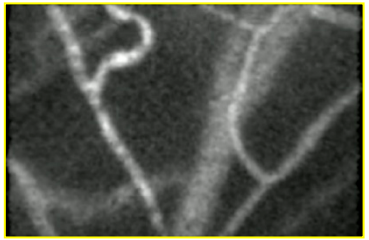
Anatomic, Functional and Molecular Imaging

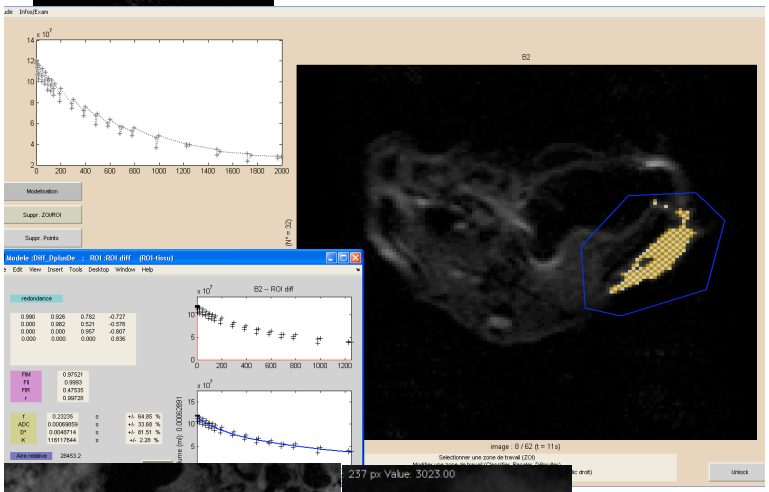




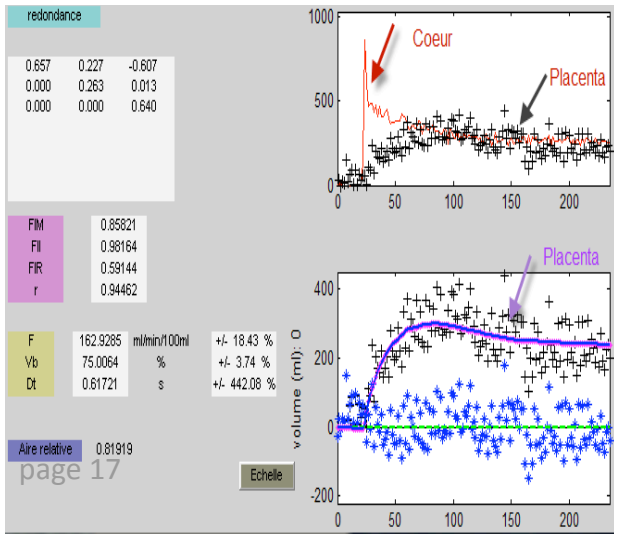


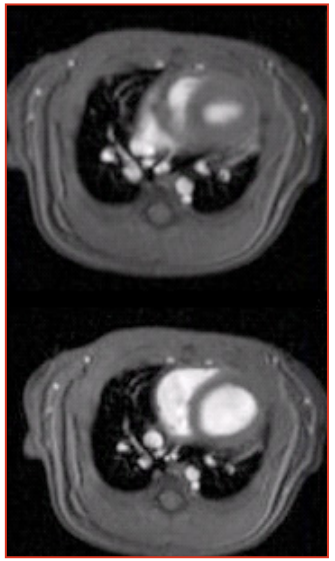






Human and small animals



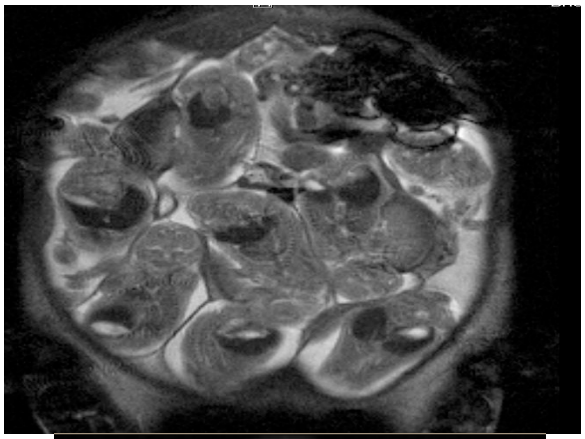


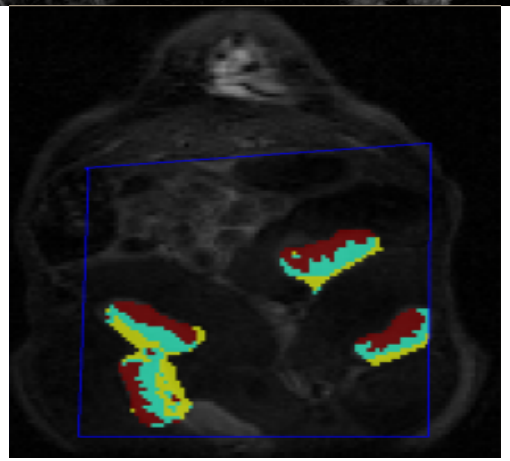
Instituts thématiques Inserm
Institut national de la santé et de la recherche médicale

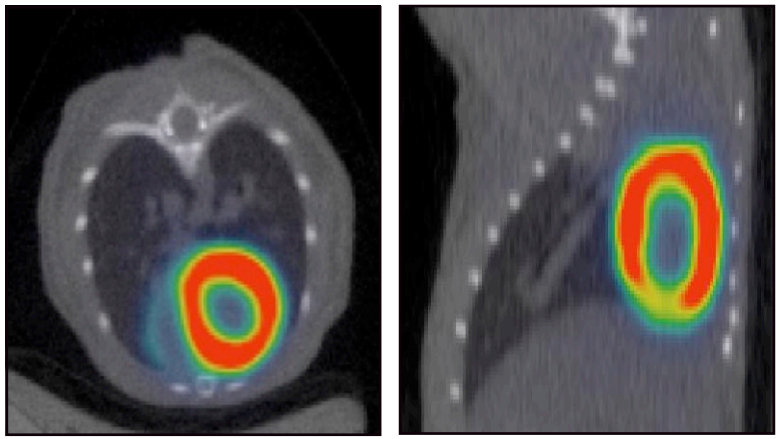
University Paris Descartes

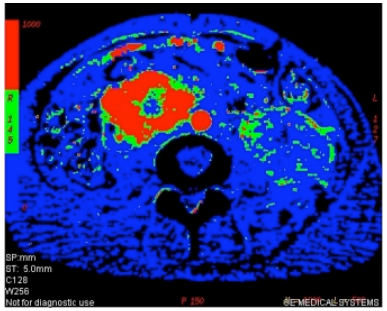
Faculty:

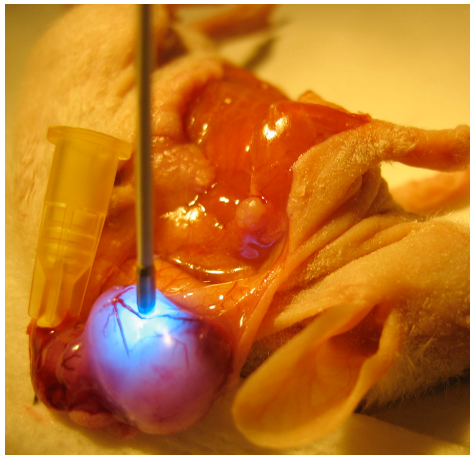
- Charles André Cuenod (ca@cuenod.net)
- Olivier Clément (olivier.clement@inserm.fr)









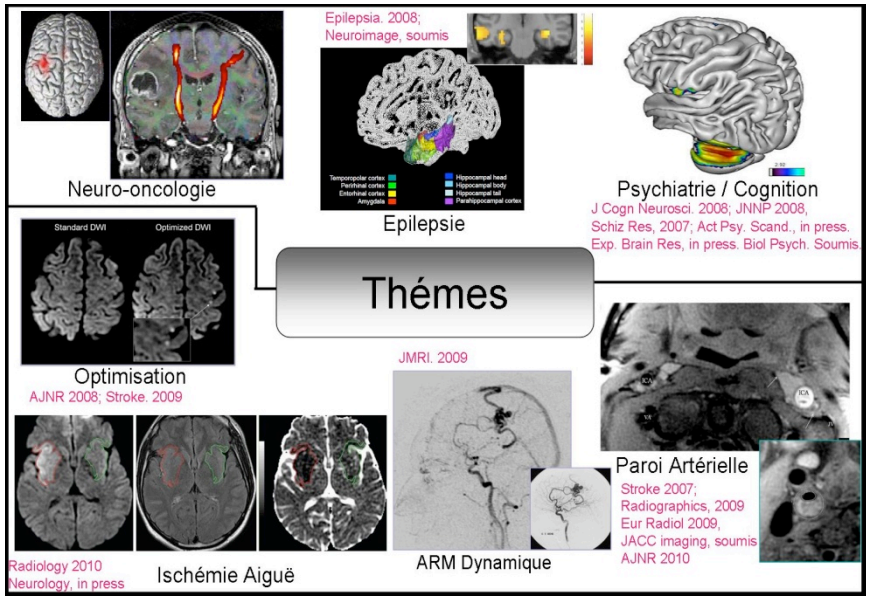


University Paris Descartes

Faculty:
- Catherine Oppenheim (C.OPPENHEIM@ch-sainte-anne.fr)

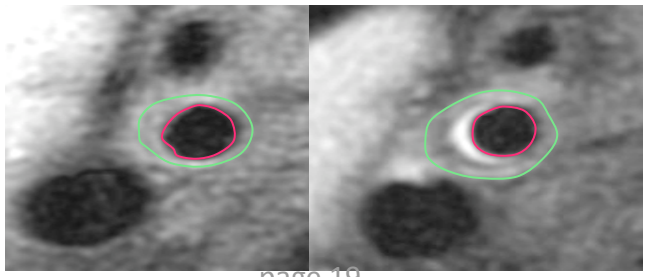
Centre Hospitalier Sainte-Anne

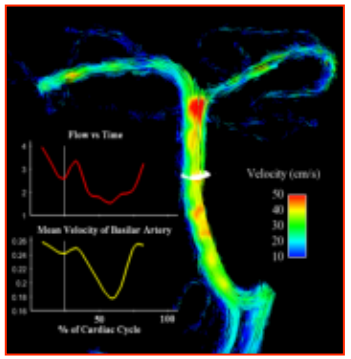
Département of Morphological and Functional Imaging



- **Imaging Resources**
  - CT 64 detectors (2008)
  - Interventional radiologu
  - Ultrasound
  - MRI 1.5 T (2008) and **3T** (2010)

- **INSERM UMR 894. Stroke Unit**

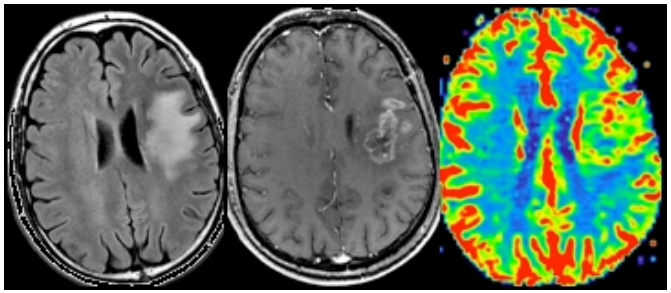




UNIVERSITÉ PARIS DESCARTES

University Paris Descartes

IDV IMAGERIE DU VIVANT



5 fields of research: Medicine, Biology, Chemistry-Pharmacology, Physics, Mathematics et Computer Science

Laboratory MAP 5

Image processing

Faculty:

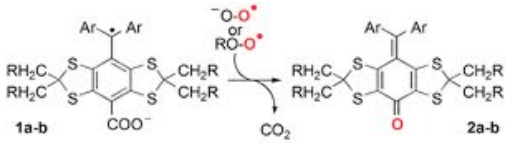
- Lionel Moisan (Lionel.Moisan@parisdescartes.fr)

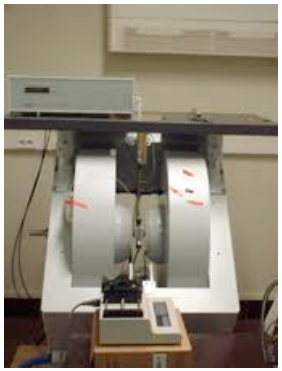
Laboratory UMR CNRS 8601

Faculty:

-Yves Frappart (yves.frapart@parisdescartes.fr)

Platform EPR imaging





Laboratory LIPADE

Image processing

Faculty:

- Florence Clopppet (florence.cloppet@mi.parisdescartes.fr)

BIM: after the M2....

- R&D engineer:
  - Main industrials of whole body screening: GE, Philips, Siemens
  - Startups in medical imaging: Supersonic, Echosens,…
  - Biological imaging: Biospace Lab, Leica,…
  - Pharmaceutical companies: Sanofi Aventis, Guerbet, …
  - Medical Imaging Software: Dosisoft,
  - Additional: L'oreal,….
- PhD :
  - Medical image processing
  - Medical imaging and Chemistry for imaging
  - Biological and optical imaging