



LabEx PRIMES
Physics, Radiobiology, Medical Imaging
& Simulation

Scientific directors :

Françoise Peyrin, DR INSERM, CREATIS

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LabEx Manager

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Context and Objectives

Context in Health

- **Cancer :**
 - 1st cause of mortality in France
- **Age related disease : increasing**
 - Neurodegenerative, cardiovascular, osteoarticular diseases
- **Scientific Objectives :**
 - Development of new concepts for the exploration, the diagnosis and the therapy of cancers and age-related pathologies
- **Lyon : node of 2 National Infrastructures**



LabEx PRIMES : Physique, Radiobiologie, Imagerie MEdicale & Simulation

- Partners

- 16 research labs from “Université de Lyon” (INSA, UCBL, Polytech, ENS, Univ St Etienne), “Université de Grenoble Alpes”, “Université d’Auvergne”, Clermont-Ferrand
- Teams : 24

- Topics

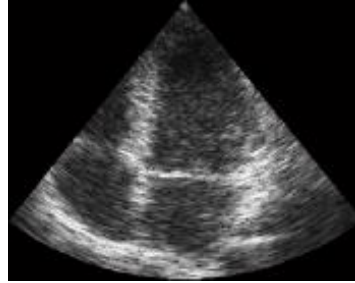
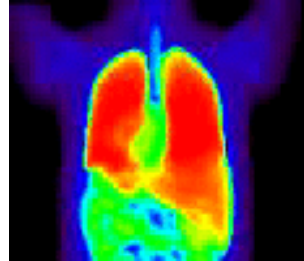
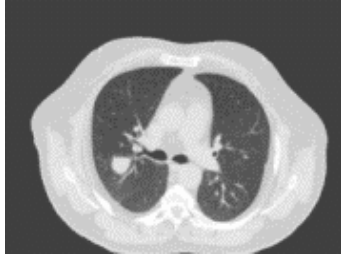
- Multi disciplinary : physics, image processing, computer science, biomedical engineering, biomechanics, biology, medicine

- People

- Permanent people : 203 (116 FTE), inclusion of new members

Technical challenges : Innovative Imaging

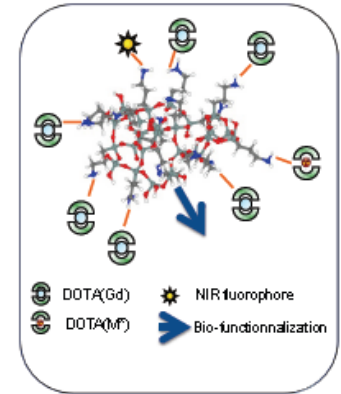
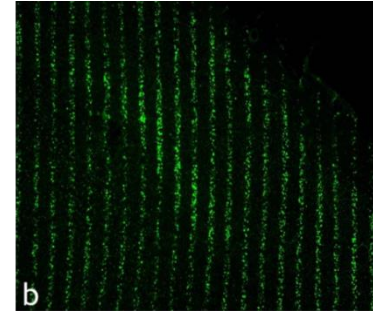
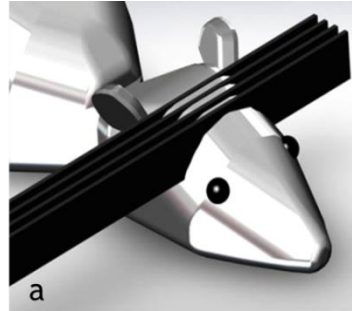
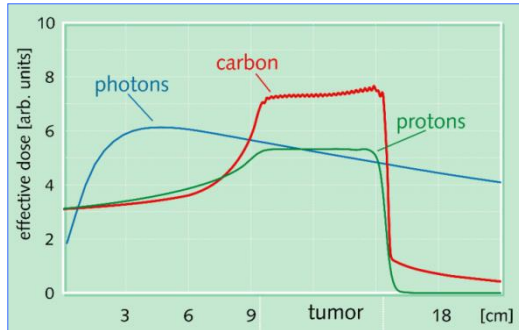
- Biomedical imaging



- **Acquisition/instrumentation** : increased in sensitivity, quantification, spatial and temporal resolution, multi modality
- **Processing** : improve image quality, extraction of relevant information, management of big data
- **Strong experience**: CREATIS, + labs computer science, LIRIS, ENS, LHC...
- **International collaboration** : VPH network, UCL London, Univ Berlin, Politecnico Milano...

Technical challenges : Innovative Radiotherapy

- **Novel RTs** : Maximize dose in tumor / Minimize dose to healthy tissue
- Hadron Therapy, Microbeam RT, PAT-Z,



- **Instrumentation** : Improve quality assurance : new tools
- **Radiobiology** : understand and predict biological efficiency
- **Simulation/Modelisation** : Improve treatment planning
- **Strong experience** : Etoile project (2001-14), IPNL, LIRIS...
- **International collaboration** : Enlight European network, Hadrontherapy centers CNAO, HIT, MedAustron...

LabEx PRIMES : Physics, Radiobiology, Medical Imaging & Simulation

Cancer

Aging

Exploration, Diagnostic, Therapy

WP1
Innov Radiotherapy

WP2
Emerging Imaging

WP3
Radiobiology

WP4
MultImageProc

WP5
Simul/Model

Valorization

Education

Fundings

- **PhDs students**

- First recruitment : 2012, ~ 1 PhD /year/WP
- Partially or totally funded by PRIMES
- 11 foreign students, 18♂, 12 ♀
- Defended PhDs : 7, On going: 23 PhDs

- **Master training**

- 25 training, ~ 2 / year / WP

- **PostDocs/engineers**

- WP1&5 (1y 2013-14), WP2 (2y 2016), WP3 (2y 2015-16), WP4 (2y 2016), WP5 (1y 2016)
- 2014 - 16 : 1 IE training platform
- 2015 - 16 : IE computing (2 y simulation US, 0.5y modeling)

Research activities

WP1 : Innovative Methods in Radiotherapy

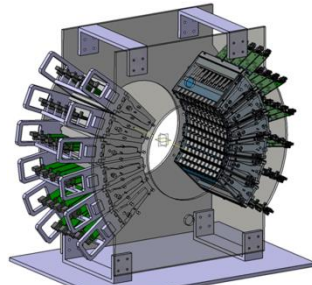
- Resp : G Montarou (LPC) et JM Létang (CREATIS)

Context :

- Hadrontherapy
- X-ray therapy: IMRT and ESRF micro-beams

Objectives :

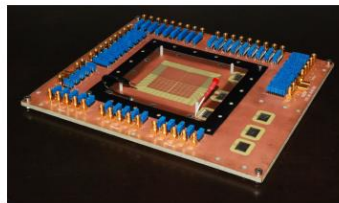
- Online control:
- Dosimetry
- Imaging ion range



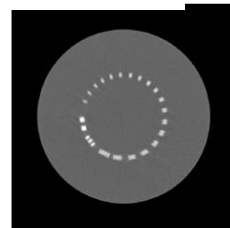
Online PET prototype and acquisition board



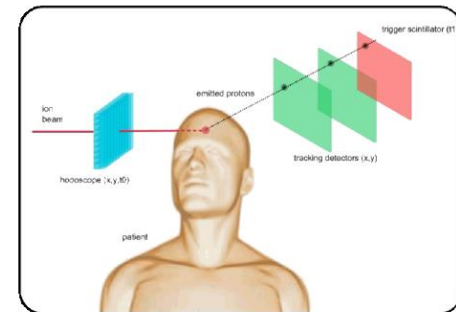
Scintillating fibers
Beam hodoscope



IMRT ionizing field
measurement prototype



Proton tomography



Proton Interaction vertex imaging

WP2 : Emerging and Innovating Imaging Techniques

- Leaders : O Beuf (CREATIS) et H Ratiney (CREATIS)

- Objectives :

- Design of new instruments, protocols or acquisition concepts (strong interactions with WP4, WP5).
- Multi-dimensional and multi-modal information

- Two main tasks:

T1: Hybrid imaging

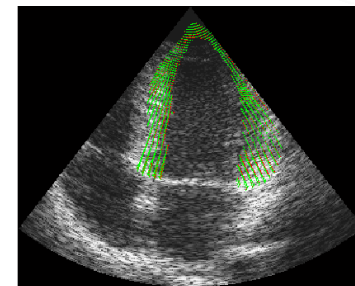
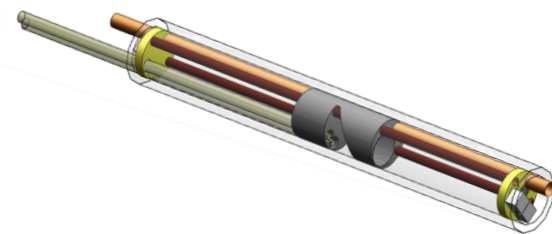
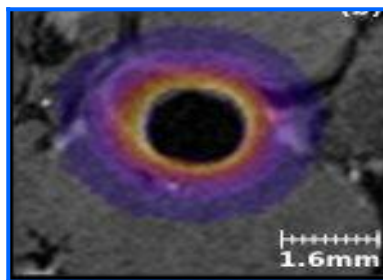
Integrated **MR/PET**,

Bi-modal **MR/optic** probe,

MR/US Elastography,

Ultra-sound/optics

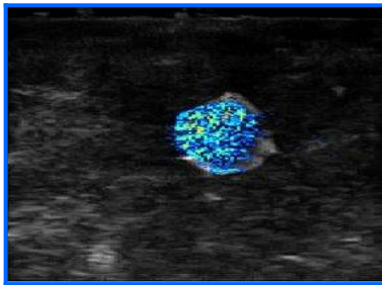
mr - pet
L i L i
hybrid imaging



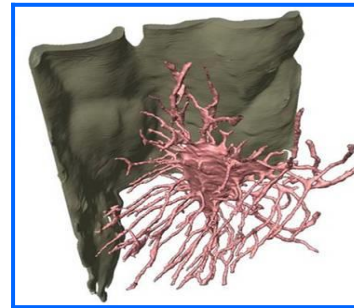
Bimodal and multiscale MR/optics to characterize and grade in vivo diseased colorectal tissues, PhD Nov 2016

WP2 : Emerging and Innovating Imaging Techniques

- Leaders : O Beuf (CREATIS) et H Ratiney (CREATIS)
- T2: Novel Imaging techniques based on new acquisition concepts
 - Cardiac MR-DTI,
 - New MR encoding concept,
 - Multi scale/functional optical imaging
 - Multi-dimensional motion estimation in echocardiography
 - Novel X-ray imaging (phase contrast and spectral CT),



Photoacoustic imaging of deep biological tissues, PhD Sept 2015, Coll LabEx CeLya



X-ray phase imaging of Bone tissue, PhD Sept 2016

WP3 : Experimental and Clinical Radiobiology, Instrumentation, Modelisation

- Resp C. Rodriguez-Lafrasse (LRCM), M. Beuve (IPNL)

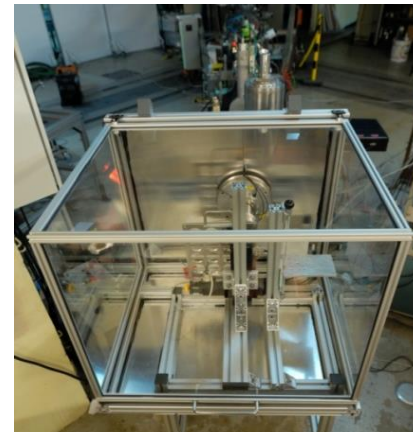
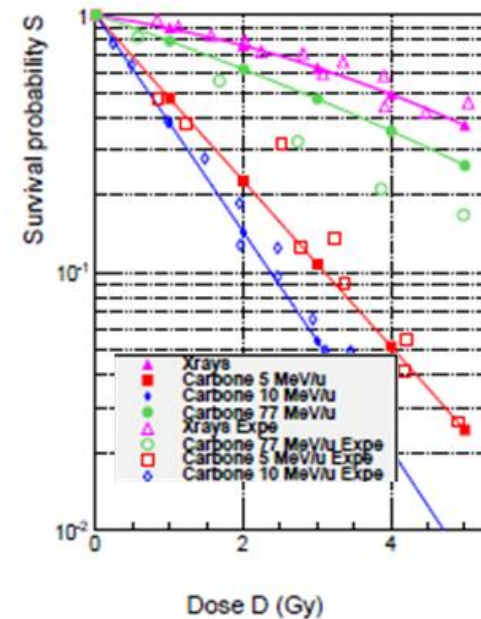
- Objectives:

Understanding, quantifying, modeling the physical, chemical and biological effects for 3 types of innovative radiotherapy (Hadrontherapy, PAT-Z, Microbeam (MRT))

- 3 axis:

- 1 : Methodology and instrumentation
- 2 : Tumor cell response
- 3 : Modeling and multi-scale simulation of radiobiological data

Cell survival
photon vs carbon dose



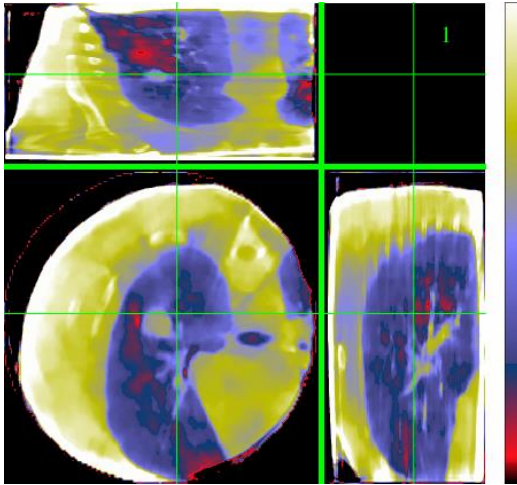
Radiograaff Proton
irradiation beam line

WP4: multi-dimensional data processing

- Resp: P. Clarysse (CREATIS), D. Friboulet (CREATIS)

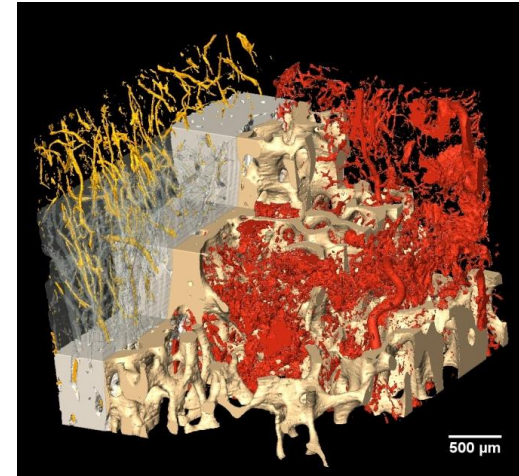
- Objectives :

1) To improve image formation
→ see better and more



Total Variation dynamic CT reconstruction
(motion correction)

2) To extract meaningful biomarkers
Get the *essence* from data ←



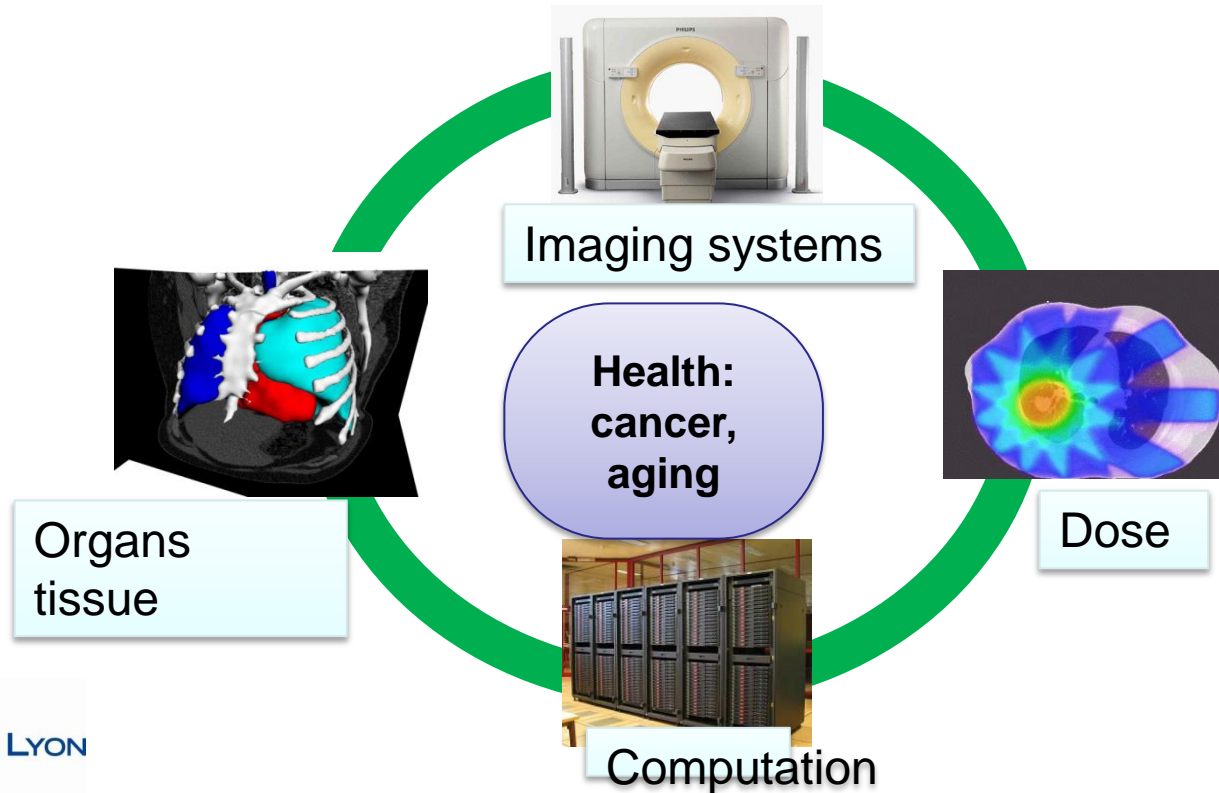
Analysis of bone microstructure and
microvascularisation (voxel : 1.4μm)

- Medical Target

Cancer Imaging and Image Guided RadioTherapy, Cardiac Imaging,
Brain Imaging, Osteo-articular Imaging

WP5 : Modeling and simulation

- Resp: D. Sarrut (CREATIS), C. Perez (LIP)
- Objectives :
 - Numerical models and simulations for virtual medical imaging, dose prediction, biomechanical modelling
 - Paradigms to manage High performance computing



Education & Valorisation

WP : Education

- Resp : D Rousseau (CREATIS), B Montcel (CREATIS)
- Objectives: initial, research and continuing education
- Practical Training room
 - Simulation platform
 - Imaging devices :
 - US
 - Optics
 - MRI
 - X-Ray

Located at INSA – GE, Open since 2015

Open to various formations (INSA, Politech, IUT, Medicine....)



WP : Education

- PRIMES summer schools
 - 2012 : coll Entervision
 - 2014 : coll “Surgical Simulators”, GdR Stic-Santé
 - 2015 (July) : **Simulation in Medical Imaging**
 - 2016 (June) : coll. OPUS - OPTical and UltraSound imaging - (*LabEx Ceylia / ITN OILTEBIA*)
 - 2014 and 2016 (Sept) : CNAO/France Hadron/PRIMES school of Hadrontherapy – Pavia, Italy



PRIMES
UNIVERSITE DE LYON

RX / TEP IRM US Grille de calcul

Ecole d'été du LabEx PRIMES
Lyon, du 6 au 10 juillet 2015

Le LabEx PRIMES organise une école thématique dans le but de promouvoir l'utilisation d'outils de simulation comme la plateforme *Virtual Imaging Platform* (VIP) en présentant les bases de la plupart des principales modalités d'imageries médicales (US, IRM, RX, TEP) et leur simulation sur grille de calcul à des fins diverses allant de la validation de méthodes de traitement d'images mono ou multimodales, la conception d'imageurs ou encore la simulation de pathologies accessibles via les imageries considérées.

L'école aura pour thème :

**-Physique de l'imagerie et simulation-
-Applications biomédicales-**

Elle comportera à la fois des cours tutoriaux, des travaux pratiques ainsi que des sessions d'échange entre participants et organisateurs.

Intervenants pour les tutoriaux :

- Ultrasons : Denis KOUAME (IRIT - Université Toulouse 3 Paul Sabatier)
- Imagerie par résonance magnétique : Hervé SAINT JALMES (LTSI - Université de Rennes 1)
- Tomographie par émission de positons : Christian MOREL (CPPM, Marseille)
- Rayons X : Nicolas ARBOR (Université de Strasbourg)
- Calcul sur grille : Sorina POP (CREATIS, Lyon)

L'école thématique est ouverte prioritairement aux jeunes chercheurs, développeurs en traitement d'images appliqué au domaine biomédical ainsi qu'aux physiciens, chercheurs ou développeurs en imagerie.

Comité scientifique local:
David ROUSSEAU (CREATIS)
Françoise PEYRIN (CREATIS / ESRF, Grenoble)
Jean-Michel LETANG (CREATIS)
Hélène RATINEY (CREATIS)
François VARRAY (CREATIS)
Voichita MAXIM (CREATIS)
Sorina POP (CREATIS)

Comité D'organisation local:
Béatrice RAYET (LabEx PRIMES)
J.B. MOURGUES (LabEx PRIMES)
Axel BONET (LabEx PRIMES)

Participation aux frais :
• Agents CNRS : Pris en charge
• Doctorants et autres personnels d'établissement

Scientific animation

- **Examples of PRIMES Meetings**
 - 2015 April: Club 3D, in coll with ReactivIP (50 part) - WP4
 - 2015 Jul: Mitochondria, nanoparticles and quantum ab initio - WP3
 - 2015 June: Diamond Detectors - WP1
 - 2015 Oct: Workshop Accelerator Based-Neutron Capture Therapies - WP1
 - 2015 Sep: Biomaterials - WP2
 - 2016 Feb: Optimal control of spin systems: imaging and NMR spectro.- WP2
 - 2016 April: Detect, quantify and simulate from micro to macro scale - WP2
 - 2016 June: Multi-scale physic and biologic dosimetry for radio- and hadron-therapy - WP3
 - 2016 July: Image registration & motion estimation, 2nd meeting for users/developers - WP4
 - 2016 Nov: Radiomic - WP2/WP4
- **Public events**
- **Partners in larger conferences, examples**
 - 2015 Sept: GRETSI, Lyon (700 part)
 - 2016 July: ESB, Lyon (1000 part)
 - 2016 Feb: 1er Congress Living Imaging (FLI), Paris
 - **2017 Mars 27-29, RITS, INSA Lyon** (<https://rits2017.sciencesconf.org/>)

Conclusion

- **Ambition :**
 - Create a significant pole in medical imaging and physics for medicine
 - Large spectrum of activity
- **Global Strategy**
 - Improve synergy between WPs and partners
 - Reinforce international collaborations, site attractiveness
- **Education and animation**
 - New programs in medical imaging and simulation
 - Organization of summer schools and meetings
- **Valorization**
 - Leverage effect
 - Increase industrial collaborations
- **Involved in the University of Lyon IDEX2 project**