

Summer School – Medical and Biological Imaging, Data processing and understanding « September 2021 »

Organizing Committee



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Marseille Imaging Institute organize a Summer School to present the different imaging modalities.

We have the chance to bring together **European and global experts** on each theme.

PLENARY SESSION

The speakers of the plenary session will introduce the thematic field for an audience that may be at the second year of master or beginning of thesis level and may come from various disciplines (physics, biology, medicine,...). The speakers will then develop aspects of the state of the art and the most recent advances.

RESEARCH FOCUS

Research focus speakers will focus on the most advanced topics related to their field, keeping in mind that the audience will not be composed only of specialists.

Although the format is digital only, we hope that this school will be an opportunity to ensure the cross-fertilization of disciplines and to promote contacts between students and researchers.

Enjoy...



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**Summer School – Medical and Biological
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MRI Imaging

6th of September – 10:00 AM



PLENARY SESSION - Alexander RAAIJMAKERS

Magnetic Resonance Imaging (MRI): The Physics Underneath and all its Applications.

Eindhoven University of Technology, Dept. of Biomedical Engineering, NETHERLANDS.
University Medical Center Utrecht, Imaging Division, NETHERLANDS.

RESEARCH FOCUS

- **Andre FERREIRA-MARTINS (1:15 PM) - Imaging tissue physiology with non-invasive metabolic approaches.**
Werner Siemens Imaging Center, University of Tübingen , 72076, Tübingen, GERMANY
- **Virginie CALLOT (2:15 PM) - Multi-parametric Magnetic Resonance Imaging of the Spinal Cord at high and ultra-high field: opportunities and challenges.**
CRMBM-CEMEREM, UMR 7339, CNRS, Aix-Marseille University, Marseille, FRANCE.
- **Luisa CIOBANU (3:15 PM) - Opportunities offered by ultra-high field MRI,**
NeuroSpin, Institut des sciences du vivant Frédéric Joliot, DRF, CEA Saclay, FRANCE



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X-RAY Imaging

8th of September – 10:00 AM



PLENARY SESSION – Anthony BUTLER

MARS 3D spectral imaging: colour x-rays for medicine.

MARS Bioimaging Ltd, 29a Clyde Road, Ilam, christchurch, NEW ZEALAND

RESEARCH FOCUS

- **Vincent VIDAL (2 PM) – Interventional imaging research**
Aix-Marseille Univ, Laboratoire d’Imagerie Interventionnelle Expérimentale, APHM,
Marseille, FRANCE
- **Christian MOREL (3 PM) - Hybrid Pixel Detectors: a translation of the search for the Higgs boson towards Photon Counting CT.**
Aix-Marseille Univ, CNRS/IN2P3, Centre de Physique des Particules de Marseille,
Marseille, FRANCE.



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OPTICAL Imaging

10th of September – 10:00 AM



PLENARY SESSION – Sandrine LEVEQUE-FORT

From fluorescence microscopy to nanoscopy for biological samples.

Univ Paris-Saclay, Institut des Sciences Moléculaires d'Orsay, CNRS UMR 8214, 91405 Orsay, FRANCE

RESEARCH FOCUS

- **Hervé RIGNEAULT** (2 PM) - **Vibrational molecular imaging: a new tool for biology and medicine.**
Aix Marseille Univ, Ecole Centrale de Marseille, CNRS, Institut Fresnel UMR 7249, 13297, Marseille, FRANCE
- **Emiliano RONZITTI** (3 PM) – **Wavefront shaping and photomodulation of neuronal activity**
Sorbonne Université, INSERM, CNRS, Institut de la Vision, F-75012 Paris, FRANCE



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NUCLEAR MEDICINE Imaging

13th of September – 10:00 AM



PLENARY SESSION – Paul LECOQ

Nuclear Imaging in Medicine : status and perspectives

CERN & Multiwave Metacrytal S.A., Geneva, SWITZERLAND

Instituto de Instrumentación para Imagen Molecular (I3M), Valencia, SPAIN

RESEARCH FOCUS

- **Eric GUEDJ** (2 PM) - **Molecular imaging in nuclear medicine, from biomarkers to theranostics**
APHM, Aix Marseille Univ, Ecole Centrale de Marseille, CNRS, Institut Fresnel UMR 7249, CERIMED, 13005, Marseille, FRANCE
- **Benjamin GUILLET** (3 PM) – **Upcoming Title**
APHM, Aix Marseille Univ, European Center of Medical Imaging, CERIMED, Camus Santé Timone, Marseille, FRANCE



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UNTRASOUND Imaging

15th of September – 10:00 AM



PLENARY SESSION – Mathias FINK

Upcoming Title

Institut Langevin, Ondes et Images, Paris, FRANCE

RESEARCH FOCUS

- **Emilie FRANCESCHINI (2 PM) - Spectral-based quantitative ultrasound imaging for tissue microstructure estimation.**
Aix Marseille Univ, CNRS, Centrale Marseille, Laboratoire de Mécanique et d'Acoustique UMR 7031, Marseille, FRANCE
- **Claude COHEN-BACRIE (3 PM) - Software based Ultrasound: a new paradigm for Point of Care and a huge market opportunity for Ultrasound**
Supersonic Imagine cofounder, current president and founder of E-Scopics, 13090 Aix-en-Provence, FRANCE



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ARTIFICIAL INTELLIGENCE for medical Image Applications

17th of September – 10:00 AM



PLENARY SESSION – Michaël UNSER

Artificial Intelligence for (bio)medical image reconstruction.

Laboratoire d'imagerie Biomédicale (LIB), Ecole Polytechnique Fédérale de Lausanne (EPFL),
Lausanne, SWITZERLAND.

RESEARCH FOCUS

- **Caroline CHAUX** (2 PM) - **Solving inverse problems in signal and image processing**
Institut de Mathématiques de Marseille, CNRS, UMR 7373, Marseille, FRANCE
- **Sophie ACHARD** (3 PM) - **Brain connectivity networks for understanding pathologies**
Univ. Grenoble Alpes, CNRS, Institut national de recherche en science et technologie du
numérique (Inria), LJK UMR 5224, 38000 Grenoble, FRANCE



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INFORMATION SPEAKERS & ABSTRACTS

MRI Imaging - 6th of September

Magnetic Resonance Imaging (MRI): The Physics Underneath and all its Applications

Alexander RAAIJMAKERS, A.J.E.Raaijmakers@tue.nl

Eindhoven University of Technology, Dept. of Biomedical Engineering, NETHERLANDS.

University Medical Center Utrecht, Imaging Division, NETHERLANDS.

MRI is an essential and extremely versatile medical imaging modality. This lecture will outline the underlying physics and the mechanisms to create an image. Furthermore, the wide range of application areas will be explored including the various contrast mechanisms that MRI can offer. Finally, also the emerging field of MRI-guided radiotherapy will be touched upon.

Imaging tissue physiology with non-invasive metabolic approaches

André F. Martins, andre.martins@med.uni-tuebingen.de

Werner Siemens Imaging Center, University of Tübingen, 72076, Tübingen, Germany

This seminar will describe multimodal approaches for imaging tissue physiology in the context of molecular imaging. It will show our most recent advances detecting and discriminating metabolites *in vivo*, using innovative paramagnetic Shift Reagents for CEST-MRI, hyperpolarized ¹³C-pyruvate MR spectroscopy, and [¹⁸F]fluorodeoxyglucose-Positron Emission Tomography ([¹⁸F]FDG-PET). Hence, this talk will comprehensively show how a solid base of several fundamental sciences in physics, chemistry, biology, and medicine can be used to detect metabolic abnormalities in health and disease.

Multi-parametric Magnetic Resonance Imaging of the Spinal Cord at high and ultra-high field: opportunities and challenges.

Virginie CALLOT, virginie.callot@univ-amu.fr

CRMBM-CEMEREM, UMR 7339, CNRS, Aix-Marseille University, Marseille, France.

The presentation is intended to give a general overview of what can be done to non-invasively characterize the healthy and pathological spinal cord. Quantitative MR methods will be presented along with the latest results obtained on human whole-body ultra-high field system (7T).





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Opportunities offered by ultra-high field MRI

Luisa Ciobanu, luisa.ciobanu@cea.fr

NeuroSpin, Institut des sciences du vivant Frédéric Joliot, DRF, CEA Saclay, Bât. 145 - PC n° 156, 91191 Gif-sur-Yvette, France

The intent of this presentation is to discuss the main advantages of imaging at ultra-high magnetic field (UHF). As low sensitivity is the most common drawback of MRI applications, the most obvious opportunity of UHF is the increased sensitivity, reflected in higher Signal-to-Noise ratio (SNR). This SNR increase can be used for faster imaging and/or higher spatial resolution. In addition, UHF offers enhanced magnetic susceptibility contrast, which enables high-resolution functional MRI studies allowing detailed characterization of neuronal activity in specific brain structures. Besides high resolution anatomical and functional MRI, UHF is also advantageous for other applications including metabolic imaging and non-proton (X-nuclei) imaging.



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X-RAY Imaging - 8th of September

MARS 3D spectral imaging: colour x-rays for medicine

Pr Anthony Butler, anthony.butler@marsbioimaging.com

MARS Bioimaging Ltd, 29a Clyde Road, Ilam, Christchurch, New Zealand

MARS Bioimaging Limited (MBI) is a medical imaging company specialised in spectral photon-counting computed tomography (CT) for quantitative colour imaging. The company was founded in Christchurch, New Zealand to commercialise the MARS imaging system for its applications in medicine. Hear from MBI co-founder and consultant radiologist, Professor Anthony Butler, about MBI's growth journey to commercialisation; starting from basic colour CT concepts and spectral imaging research to taking colour CT to the clinic.

Interventional imaging research

Vincent VIDAL, Vincent.vidal@ap-hm.fr

Aix-Marseille Univ, APHM, Laboratoire d'Imagerie Interventionnelle Expérimentale, Marseille, France

Hybrid Pixel Detectors: a translation of the search for the Higgs boson towards Photon Counting CT

Christian Morel, morel@c ppm.in2p3.fr

Aix-Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France;

Hybrid pixels were originally developed for charged particle tracking in high energy physics. They now represent a true technology breakthrough when applied to X-ray imaging. Hybrid pixels combine a Si, GaAs or a CdTe sensor consisting in thousands of pixels of a few hundreds of microns bump bonded to data acquisition microcircuits. Used as photon counters, each pixel detects every impinging X-ray that has an energy above one or two thresholds. Applied to X-ray CT, this allows to improve image contrast and to lower exposition dose with respect to traditional charge integration detectors. Moreover, in contrary to CCDs or CMOS cameras, photon counting provides access to the energy of the detected X-rays. This enables the development of spectral CT where the energy of the detected X-rays is analyzed to identify given elements according to their K-edge energy. Hence, the development of hybrid pixels will lead to a new molecular imaging modality that will be intrinsically anatomic and functional. I will present research and development on hybrid pixel detectors carried on at CPPM in the framework of France Life Imaging for preclinical Photon Counting CT.



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OPTICAL Imaging - 10th of September

From fluorescence microscopy to nanoscopy for biological samples

Sandrine Levêque-Fort, sandrine.leveque-fort@u-psud.fr

Univ Paris-Saclay, Institut des Sciences Moléculaires d'Orsay, CNRS UMR 8214, 91405 Orsay, France

Fluorescence microscopy is widely used for specific imaging of biological samples, but is restricted in spatial resolution ($\sim 250\text{nm}$ x,y, $\sim 650\text{ nm}$ z) due to the diffraction limit. We will review the different strategies to overcome this limit and allows to decipher 3D organization of proteins at the nanoscale.

Imagerie moléculaire vibrationnelle : un nouvel outil pour la biologie et la médecine

Hervé Rigneault, herve.rigneault@fresnel.fr

Aix Marseille Univ, Ecole Centrale de Marseille, CNRS, Institut Fresnel UMR 7249, 13297, Marseille, France

Biomolecules can be viewed directly by light microscopy by measuring their vibrational modes, and this in complex environments such as cells and tissues. This presentation presents the main lines of research and achievements in vibrational spectroscopic imaging, starting from basic concepts and moving towards applications.

Wavefront shaping and photomodulation of neuronal activity

Emiliano RONZITTI, Emiliano.ronzitti@inserm.fr

Orbonne Université, INSERM, CNRS, Institut de la Vision, F-75012 Paris, FRANCE



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NUCLEAR MEDICINE Imaging – 13th of September

Nuclear Imaging in Medicine : status and perspectives

Paul Lecoq, paul.lecoq@cern.ch; paul.lecoq@metacrystal.ch; plecoq@upvnet.upv.es
CERN, Geneva, Switzerland, Multiwave Metacrystal S.A., Geneva, Switzerland
Instituto de Instrumentación para Imagen Molecular (I3M), Valencia, Spain

Among the different imaging modalities used in medicine, nuclear imaging and in particular positron emission tomography (PET) offers a sensitivity at the picomolar level, allowing to decipher the complex molecular pathways involved in different metabolic processes in our body, which can be altered by a disease.

The first part of the talk will explain the principle of nuclear imaging and give examples of different applications. In a second part, new challenges and perspectives offered by rapid progress in emerging technologies will be presented

Molecular imaging in nuclear medicine, from biomarkers to theranostics

Eric GUEDJ, eric.guedj@univ-amu.fr
APHM, Aix Marseille Univ, Ecole Centrale de Marseille, CNRS, Institut Fresnel UMR 7249,
CERIMED, 13005, Marseille, France

Nuclear medicine, through SPECT and PET devices and the evolution towards morpho-functional imaging, is a major contributor to developments in personalized medicine by providing quantitative biomarkers of molecular signatures. Molecular imaging biomarkers are developed to select patients, and also in a medico-economic view, to guide, predict and evaluate most appropriate treatments, including emergent therapies, according to the characterization of molecular signature of the disease and of the lesions. This molecular complexity is closely linked to the prognosis of the disease, but also to specific treatments developed to be directed towards a same pathophysiological target for diagnosis and therapy with the concept of companion drugs and theranostics.

Upcoming title

Benjamin Guillet, benjamin.guillet@univ-amu.fr
APHM, Aix Marseille Univ, European Center of Medical Imaging, CERIMED, Camus Santé
Timone, Marseille, FRANCE



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ULTRASOUND Imaging - 15th of September

Upcoming title

Mathias Fink, mathias.fink@espci.fr

Laboratoire Institut Langevin, Ondes et Images, Paris, FRANCE

Spectral-based quantitative ultrasound imaging for tissue microstructure estimation

Emilie Franceschini, franceschini@lma.cnrs-mrs.fr

Aix Marseille Univ, CNRS, Centrale Marseille, Laboratoire de Mécanique et d'Acoustique UMR 7031, Marseille, France

Quantitative ultrasound techniques using the spectral analysis of backscattered signals aims to quantify tissue microstructure. This talk presents the background of spectral-based quantitative ultrasound techniques, as well as the latest developments on theoretical scattering models and challenges for clinical applications. Finally, some examples of successful (pre)-clinical applications are given, demonstrating the ability of quantitative ultrasound to enhance medical diagnostics.

Software based Ultrasound: a new paradigm for Point of Care and a huge market opportunity for Ultrasound

Claude COHEN-BACRIE, Claude.cohen-bacrie@e-scopics.com

Co-Fondateur Supersonic Imagine, actuel Président et fondateur de E-Scopics, 13090 Aix-en-Provence, France

Software based Ultrasound has been put on the market in 2010 with a new generation of premium systems that have leveraged Ultrafast Imaging for new wave of innovations in Ultrasound. These new more of quantitative imaging have progressively validated by the clinical community and used as imaging biomarkers. They have the potential to provide direct diagnostic informations to clinicians without any imaging interpretation skills, outside radiology. When this concept is miniaturized, it represents a unique opportunity for ultrasound to democratize itself to several clinical specialties as well as GPs and grow the market of point of care with new generation ultraportable devices.



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ARTIFICIAL INTELLIGENCE Medical Image Applications - 17th of September

Artificial Intelligence for (bio)medical image reconstruction

Michaël Unser, michael.unser@epfl.ch

Biomedical Imaging Group, Ecole Polytechnique Fédérale de Lausanne (EPFL) & Laboratoire d'imagerie Biomédicale (LIB), Lausanne, SWITZERLAND.

Artificial Intelligence for medical image reconstruction:

From physics-based to data-based techniques for image reconstruction

Solving inverse problems in signal and image processing

Caroline CHAUX, caroline.chaux@univ-amu.fr

CNRS, Institut de Mathématiques de Marseille, UMR 7373, Marseille, FRANCE

During this presentation, I will talk about inverse problems starting from models (understanding the acquisition process), then addressing their resolution (formulated as an optimization problem) while considering the parameters or hyperparameters involved all along the process (e.g. noise nature/intensity, regularization parameters).

I will illustrate these concepts in diverse situations arising in signal and image processing.

Brain connectivity networks for understanding pathologies

Sophie Achard, sophie.achard@univ-grenoble-alpes.fr

Univ. Grenoble Alpes, CNRS, Inria, LJK UMR 5224, 38000 Grenoble, France

Brain connectivity is now used frequently to model the functioning of the brain as a network. Several studies show reproducible network patterns as soon as the imaging sequence is of good quality. Brain pathologies can be characterized by a change in networks pattern. In this talk, I will give some guidelines to model the brain as a network using neuroimaging datasets. To conclude, illustrations of the disruption of networks under pathologies will be described.



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