

**9:00 Introductory speech | Philippe Odier | ENS de Lyon Physics Laboratory - Lyon**

*Philippe Odier is an associate professor at the Physics Laboratory of the École Normale Supérieure de Lyon.*

**9:20 Conférence #1 | Winfried Mayr | Medical University of Vienna - Vienna**

### The role of electrical parameters and electrodes in FES supported motor control

Technical developments of neural prostheses started mid 20<sup>th</sup> century and resulted in continuous improvements of applicable instrumentation over the years. Most critical limitations have been, and are still, in the coupling of the technical systems to the physiological structures to be excited, with critical selectivity and safety issues.

Stimulation currents pass an interface between electrode, which is a technical electron conductor, and living organism, which is an electrolyte, with ions conducting. This interface is characterized by electrochemical phenomena, with associated risks of electrode corrosion and tissue damage, but in addition also by instabilities and geometrical limitations in mechanical coupling of electrodes and complex tiny anatomical structures. Necessary minimum size of electrodes and minimum distance of their placement in relation to activation targets, and time dependent adaptive tissue reactions to electrodes as foreign body objects and to artificial charge injection have remained main challenges in all development efforts.

The resulting bottleneck is often underestimated and not enough considered in development goals and interpretation of observations in experimental or clinical application. A critical analysis of realistically possible recruitment of – in most cases – neuron populations under given electrode configurations and stimulus parameters and resulting neurophysiological processes is the essential key for understanding what benefits can be accomplished by means of electrical stimulation, where we face limitations, and how we can ensure safe and effective operation.

*Winfried Mayr is an associate professor at the Center for Medical Physics and Biomedical Engineering. Beyond his holistic view, including sensor and measurement technology, active and passive medical implants, biomechanical and surgical instrumentation, with strong focus to Functional Electrical Stimulation (FES), implant technology and rehabilitation engineering, he is bridging to external academic and industrial expertise and partnership, from research collaboration to application transfer of novel product solutions and methodologies*

**10:00 Conférence #2 | Lana Popovic-Maneski | Institute of Technical Sciences of the Serbian Academy of Sciences and Arts (SASA) - Belgrade**

### How to bring FES to everyday use: bottlenecks and available solutions

FES can be defined as a pacemaker for movement. The benefits of FES for the metabolism of a person in the wheelchair are far reaching. Exercise of functional movements with increased afferent inputs after stroke, cerebral palsy, traumatic brain injury, and other types of neurological injury increases the effects of brain plasticity to motor recovery. It can be used in coma to prevent muscle loss or after surgery to increase the recovery of the lost muscle mass. Healthy persons can use FES to increase strength and endurance. So, why don't we often find FES in rehabilitation institutions, intensive care or fitness rooms? Before FES reaches the mass market, we should eliminate effectively several key bottlenecks by designing systems that allow easy donning and setting the stimulation parameters, decreased muscle fatigue and good selectivity.

*Lana Popovic-Maneski is a research associate at the Institute of Technical Sciences of the Serbian Academy of Sciences and Arts. She is also the founder and CEO of 3F (Fit Fabricando Faber), a start-up dedicated to the development of technologies for assisting persons with special needs. The company is making efforts to translate R&D results into innovations.*

**10:50 Conférence #3 | Christophe Clanet | École Polytechnique Hydrodynamics Laboratory (LadHyX) - Paris**

### Physics of road and track cycling

Tour de France, Giro d'Italia and Vuelta in Spain are the three Grand Tours of professional road cycling. Three weeks long with daily stages, these three races all use three jerseys to distinguish the leader, the best sprinter and the best climber. We will first discuss the physics of road cycling and show that these three jerseys are respectively associated with three different dynamical regimes.

We will then propose a phase diagram for road cycling which enables to discuss the different physiological characteristics observed in the peloton.

For track cycling we will first analyse the Individual pursuit of Graham Obree world title in 1993. We will then move to the qualifying 200 m of Jason Kenny and finish with team pursuit. The main point will be to discuss why and how the fixed gear condition of track cycling changes the law of races.

*Christophe Clanet is a CNRS research director and professor at École Polytechnique. He is currently the director of the academic innovation cluster Science 2024.*

**Conférence #4 | Mai-Anh Ngo (in French) | Law, Economics & Management Research Group (GREDEG)-Sophia Antipolis**

### Le décret “sport sur ordonnance” : vraie ou fausse bonne idée pour la rééducation des personnes en situation de handicap ?

Le dispositif sport sur ordonnance est instauré par le décret n° 2016-1990 du 30 décembre 2016. Ce texte, dont la majeure partie s'intègre au Code de la santé publique, symbolise la consécration législative par le droit français de l'activité physique comme une thérapeutique non médicamenteuse prescrite par les médecins.

Ce décret aurait pu représenter une évolution extrêmement intéressante dans une perspective de rééducation des personnes en situation de handicap. En effet, le sport favorise des améliorations physiques, mais présente également des bénéfices sur le plan psychologique et social, en particulier. Cependant, la rédaction en l'état actuel du texte ne permet pas au dispositif sport sur ordonnance de jouer ce rôle central dans la rééducation et la réadaptation des personnes en situation de handicap.

*Mai-Anh Ngo est docteure et HDR en droit, ingénieure de recherche au laboratoire GREDEG. Ses thèmes de recherche sont le droit du handicap et du sport. Ancienne handisportive de haut-niveau, elle siège notamment à la Commission juridique du Comité National Olympique et Sportif Français. Elle est l'actuelle secrétaire générale de la Fédération Française Handisport.*

**Conférence #5 | Yves Rossetti | Neurosciences Research Center (CRNL) - Lyon**

### Neurophysiology and neurostimulation: acting at all levels | part. 1/2

This presentation aims at reviewing the principles of organisation of the sensori-motor system as well as its plastic capacities. One interesting focus on this topic is to distinguish between sensorimotor learning and adaptation processes, as they lead to radically different properties of generalisation of the training in everyday life. We will specifically emphasize the potentially important expansion of sensorimotor adaptation to numerous functions. Beyond this level we will review the main current targets for further stimulating brain plasticity.

*Yves Rossetti is professor of physiology at Lyon medical school and Hospices Civils de Lyon (HCL), head of the "Mouvement et Handicap" platform for the multimodal analysis of human movement of HCL/CRNL, and head of the Trajectoires team of Lyon Neuroscience Research Centre (CRNL), a patient-centred project aimed at developing research for sensory, motor and social handicap. He has been investigating visuomotor coordination and spatial cognition and their plasticity for 30 year and contributed to several diagnosis and rehabilitation procedures in the field.*

**Conférence #6 | Perrine Seguin | INSERM / Jean Monnet University - Saint Étienne**

### Neurophysiology and neurostimulation: acting at all levels | part. 2/2

The aim of modern rehabilitation is to offer a patient-centered approach based on neurophysiological knowledge. We will give an overview of the current conception of the organization of the sensori-cognitive-motor system. We will then present how neurostimulation and brain-computer interfaces approaches can be applied at different levels of this neurophysiological organization. Finally, we will discuss the various challenges addressed by neurotechnologies in ecological settings.

Since several decades, neurotechnologies such as neurostimulation and brain-machine interfaces raise much hope for restoring the autonomy of people with disabilities. However, after several decades of technological improvements, they are struggling to impose themselves in the daily life of people with disabilities. We will address here two points which appear to be crucial to allow a revolution in the usability of these devices. First of all we need to better understand the functioning of the nervous system, and therefore strongly depend on advances in fundamental neurosciences. And in parallel we should take more into account the needs and aspirations of people with disabilities.

*Perrine Seguin is a medical doctor in Physical and rehabilitation medicine since 2018. She did a master's degree in Biomedical Engineering in neurosciences in Paris (ESPCI & Paris Descartes) and is currently a PhD student in the Lyon Neuroscience Research Center. She works on brain-computer interfaces for persons with paralysis. She is also involved in the organization of the Hacking Rehab Lyon 2020 : <https://hackingrehablyon.wixsite.com/hrl2020>*

### **Conférence #7 | Lucie Dalibert | S2HEP / Claude Bernard University - Lyon**

#### **Knowledge, know-how & resilience strategies: how technologies are shaping bodies and disabilities**

The academic background of this talk lies in both philosophy of technologies, and social studies in sciences and technologies. Lucie Dalibert will question the way technologies are transforming the bodies, along with our conception of handicap. To this end, she will refer to various field researches that bring into play invasive biomedical technologies. She will shed light on how these technologies affect the way we experience our body and perceive handicap, along with the resilience techniques users are putting up in order to cope with these technologies.

*Lucie Dalibert is a lecturer at S2HEP laboratory, and at the College of Humanities and Social Sciences, of the Claude Bernard University Lyon 1. At the crossroads between philosophy of technology, science & technology studies and gender studies, her research focuses on how biomedical technologies are shaping our bodies and health.*

### **Conférence #8 | Vance Bergeron | ENS de Lyon Physics Laboratory - Lyon**

#### **Functional Electrical Stimulation Cycling: an Electrifying Sport**

Functional Electrical Stimulation (FES) is a method that uses weak electric fields to trigger action potentials, which provoke nerve impulses leading to muscle contractions. When contractions are properly sequenced, the muscle activity can produce movement which has functional outcomes such as; standing, ambulation, grasp-to-reach and other practical movements. This method is particularly useful to actuate paretic muscles in the physically disabled, allowing them to gain autonomy and improve their health through participation in physical activities.

In this presentation the technical details concerning how FES cycling is accomplished will be described. We will also provide a historical background of FES cycling and highlight new strategies that are being used to enhance performance, such as spatially distribute sequential stimulation, SDSS, for combating muscle fatigue. We will also discuss practical challenges and the development of new devices that are designed to be more user-friendly so that FES cycling can be used in daily activities for sport and transportation.

*Vance Bergeron is a French-American CNRS Research Director in the Physics Department at the Ecole Normale Supérieure de Lyon, France. Following a bike accident in 2013 that left him tetraplegic, he re-established his research to focus on a translational approach for Advanced Neurorehabilitation Therapies and Sport (ANTS). Gathering regional and international experts to work with him and his association "ANTS" they provide patients with state-of-the-art rehabilitation tools and organize recreational therapies. Vance competed as a FES pilot in the 2016 Cybathlon.*