PROGRAMME

Time	Speaker-s
8:30 – 8:45	Introduction to the Joint Workshop
	Session 1: Innovation within Brain Implants: pioneering BMIs
8:45 – 9:05	Brice Bathellier – *Institut Pasteur | HearLight*
9:05 – 9:25	Hans Scherberger – *DPZ | B-CRATOS*
9:25 – 9:45	Fabien Sauter-Starace – *CEA DTIS | NEMO-BMI*
9:45 – 10:05	Paul Wanda – *Blackrock Microsystems Europe | B-CRATOS*
10:05 – 10:25	Paul Le Floch – *CEO of Axoft*
10:25 – 11:00	***Coffee break***
11:00 – 11:40	1st Panel Session with the 5 speakers – moderator: Tania Rinaldi Barkat
	Session 2: Mind Meets Machine: evolutions within communication
11:40 – 12:00	Robin Augustine – *Uppsala University | B-CRATOS*
12:00 – 12:20	Charles Rezaei-Mazinani – *Institut Pasteur | HearLight*
12:20 – 12:40	Ali Khaleghi – *NTNU | B-CRATOS*
12:40 – 13:20	2nd Panel Session with the 3 speakers – moderator: Fabien Sauter-Starace
13:20 – 14:30	***Lunch break***
	Session 3: Prospects about the Machine-Humans Interactions
14:30 – 14:50	Marco Controzzi – *Scuola Superiore Sant'Anna | B-CRATOS*
14:50 – 15:10	Guillaume Charvet – *CEA DTIS | NEMO-BMI & Reverse-Paralysis*
15:10 – 15:30	Henri Lorach – *EPFL | NEMO-BMI & Reverse-Paralysis*
15:30 – 16:00	***Coffee break***
16:00 – 16:40	3rd Panel Session with the 3 speakers – moderator: Paul Wanda
16:40 – 17:00	Closing remarks

ABSTRACTS AND SPEAKERS

SESSION 1 –

INNOVATION WITHIN BRAIN IMPLANTS: PIONEERING BMIS

- ### Encoding algorithms for sensory rehabilitation implants
  Brice Bathellier – Institut Pasteur

Channelling high throughput information to the brain is not only about building stimulation device with high channel densities, but also about formatting the stimulation signals to build a consistent code interpretable by underlying brain circuits. The opportunities and challenges related to the design of appropriate encoding algorithms for brain stimulation will be discussed.

Brice Bathellier is a French neuroscientist and CNRS research director at the Institut de l'Audition, Institut Pasteur, Paris. He previously worked at CNRS-UNIC and held postdoctoral positions in Vienna and Bern. Bathellier earned his PhD from EPFL Lausanne in 2007 and his Habilitation in Neuroscience in 2015. He has received several awards, including the Foulon Prize and Emergence Prize. He leads significant research projects, such as the ERC CoG Grant and H2020 "Hearlight." Bathellier is also active in scientific committees and editorial boards, specializing in sensory and multisensory perception.

- ### Cortical hand movement prosthetics
  Hans Scherberger – Deutsches Primatenzentrum GmbH

Hand function plays an important role in all primate species, and its loss is associated with severe disability. Grasping movements are complex actions for which the primate brain integrates sensory and cognitive signals to generate meaningful behavior. To achieve this computation, specialized brain areas are functionally connected in the parietal (anterior intra parietal area, AIP), premotor (area F5), and primary motor cortex (M1 hand area). This presentation will highlight recent results to decode hand actions from neuronal population signals in non-human primates, e.g., for operating a neural prosthesis.

Hans Scherberger received his Master in Mathematics (1993) and his Medical Doctor (1996) from Freiburg University, Germany. He currently heads the Neurobiology Lab at the German Primate Center and is Professor for Primate Neurobiology at Göttingen University (since 2008). He was trained in systems electrophysiology at the University of Zurich (1995-1998) and the California Institute of Technology (1998-2003) before leading a research group at the Institute of Neuroinformatics at Zurich University and ETH (2004-2009). His research focuses on neural coding and decoding of hand movements and their interactions with sensory systems.

- ## Design and clinical validation of WIMAGINE®, a BMI wireless ECoG implant

  Fabien Sauter-Starace – CEA-Clinatec

In the field of implanted Brain Computer Interface, there are very few devices providing high resolution, long-term and stable performances. CEA started its own research in the field in 2008 first developing an Integrated circuit dedicated to ElectroCorticoGram recording. The so-called CINESIC32 chips are embedded in the WIMAGINE® implant that includes wireless communication, remote power supply in a titanium housing hermetically sealed and a 64-electrode array. In this presentation, we will focus on the development process of this implant and the long-term return on experiment gathered in the framework of two clinical trials.

Fabien Sauter-Starace received the Engineer diploma from the Arts et Métiers (Paris) and PhD in Mechanics and Material Science. Since 2008 at the biomedical research center CLINATEC®, he has been in charge of the technological developments of Active Implantable Medical Devices mainly about WIMAGINE® CEA's wireless ECoG device. Fabien is also managing of EIC NEMO-BMI for CEA an EIC pathfinder project aiming at developing adaptive real-time decoder embedded in a portable device for Brain machine interface.

- ## Modern Brain Computer Interface Platforms: The Need for Next-Generation Wireless Technologies

  Paul Wanda – BlackRock Microsystems

Dozens of human research volunteers have been successfully implanted with penetrating multi-electrode arrays in studies seeking to develop techniques to restore or replace complex functions lost due to injury or disease. Despite supporting incredible progress in this field, the research systems have typically used percutaneous connectors and bulky external hardware to acquire the high-quality neural signals needed to enable complex "BCI" control, and as a result, may be ill-suited for a broader market due to real-world practical needs. Currently, wireless technologies for both data and powering have been integrated into the latest generations of similar implantable medical platforms on the market, such as pacemakers, deep brain stimulators, and cochlear implants. Reviewing current and planned BCI clinical trials, it is evident that most leading groups see the everyday BCI platform of the future as a fully implantable wireless system. However, unlike with other platforms, a BCI system places much greater strain on existing market-ready wireless technologies due to the need for high bandwidth neural data. The B-CRATOS project has aimed to demonstrate several new wireless technologies in a brain-computer interface platform to surpass current-day constraints on data rate and powering. Here, we will review the technologies supporting various BCI platforms of the future and consider the role of the B-CRATOS neural bypass platform technologies in further advancing the safety and usability of future BCI systems.

Paul Wanda is an experienced biomedical engineer and project manager with several years' experience in smart closed-loop record/stim neural interface systems. His primary role is to provide Work Package leadership (WP5, WP7), especially coordinating system integration and exploitation. Prior to his participation in the B-CRATOS consortium, Paul was project manager at the University of Pennsylvania for the DARPA Restoring Active Memory (RAM) project to develop closed-loop stimulation solutions to restore memory function. He is currently employed by Blackrock Microsystems Europe GmbH and resides in Cologne, Germany.

- ## Novel materials and electronics for soft neural interfaces

  Paul Le Foch – Axoft

Chronically recording and stimulating deep brain regions with high-resolution for Brain-Computer Interfaces remains challenging due to various mechanical instabilities of rigid depth electrodes and the foreign body response around implants.

Axoft demonstrates the possibility to design ultrasoft probes enable chronically stable (> 1 year), single- and multi-units recordings in animal models by leveraging novel soft polymer materials. Long-term immunohistology reveals significantly lower levels of tissue damage and gliosis compared to commercial stereo-EEG and flexible probes. The ultrasoft probes enable high-resolution and high-density neural interface with cortical and subcortical structures using standard stereotaxic surgery. This work outlines the potential for clinical translation of ultrasoft neural probes for acute and chronic neural interfaces.

Paul Le Floch obtained his Ph.D. in Materials Sciences and Mechanical Engineering from Harvard University in 2021 and Masters from the French universities Mines Paris and ESPCI Paris. Dr. Le Floch is a Gold winner of the graduate student award from the Materials Research Society for his work on soft neural interfaces and was recognized in Forbes 30 Under 30 in the Science category. He is currently Co-Founder and CEO at Axoft, an early-stage start-up spun out from Harvard University developing implantable Brain-Computer Interface to enable communication for minimally conscious patients.

SESSION 2 –

MIND MEETS MACHINE: EVOLUTIONS WITHIN COMMUNICATION

- **Fat – Intra Body Communication: A new paradigm for intra-body communication technology enabling reinstatement of lost functionalities in human**

  Robin Augustine – Uppsala University

  Intra body communication has been researched quite extensively for past couple of decades to serve the needs in real time monitoring, drug delivery, sensing for pre-emptive measures and to provide better quality of living to the population. The applications are not just limited to health care but also span the areas of recreation, sports and information technology. A handful of intra body, more specifically human body centric (HBC) communication modalities have been developed so far namely galvanic, capacitive and inductive methods. Human body or part is used as a communication channel in these technologies. Though they offer the possibility to connect devices and transfer data wirelessly from one part of the body to the other they suffer from one common drawback which is the low bandwidth hence lower data rates. Radio frequency communication has been regarded until recently as an improbable candidate for extensive HBC applications. In 2016 the Asan et. al from the Microwaves in Medical Engineering Group, Uppsala University, Sweden published her first paper on the feasibility using the adipose tissue to transmit Microwave signals inside the body with significantly low loss (2dB/cm) [1]. Since then, a number of articles have been published on different aspects of fat – intrabody communication (Fat-IBC) [2-6]. Considering the human anatomy, the fat tissue is found to be sandwiched between denser tissues such as skin and muscle. As it is known that the fat due to its very low water content has low permittivity and losses while muscle and skin do have almost an order of magnitude high permittivity and losses which is three to four times that of fat. This creates a natural wave guiding structure which we can utilize to transmit microwave signals at ISM frequencies. Fat- IBC pushes further the current limits in intra-body data transfer by providing a higher bandwidth and enabling better power management to ensure longer implanted battery life. Fat channel communication will also help substantially the development of artificial limbs which require transfer of high-volume electrophysiological data, wirelessly.

Robin Augustine received Master's degree in Electronics (Robotics) from Cochin University of Science and Technology, India, in 2005. He received Doctoral degree in Electronics and Optic Systems from Université Paris Est Marne La Vallée, Paris France 2009. He had been Post-Doctoral researcher at IETR, Rennes, France until 2011. He joined Uppsala University as senior researcher in 2011. He is now Associate Professor in Medical Engineering at Uppsala University. His research field includes wearable antennas, microwave phantoms, dielectric characterization, Bionics, mechatronics, Non-invasive Diagnostics, clinical trials, animal trials, in and on body microwave communication. He has pioneered the Fat – Intra Body Communication technique and has authored or coauthored more than 200 conference and journal articles. Robin is the founder, chairman and CTO of the Swedish medtech company Probingon AB. He is currently coordinating EU HORIZON 2020 FET-Open B-CRATOS and involved in several other European large-scale projects.

• Multi-conductive layer flexible bioelectronic implants for neural recording and stimulation

Charles Rezaei – Ecole des Mines, Department of Bioelectronics

Advancements in flexible bioelectronic implants are enhancing minimally invasive neural activity recording and stimulation. Increasing electrode density by superimposing conductive leads, is one of the major approaches for fabrication of high-resolution implants. The superimposition can enhance the number of electrodes without increasing device width, but this introduces crosstalk issues due to capacitive coupling (CC). We present an investigation into CC in devices containing multi-gold layer thin-film arrays, based on PEDOTSS electrodes, and with parylene C (PaC) insulation layer between leads. These results show that capacitance due to CC decreases non-linearly and then linearly with increased insulation thickness. We identify an optimal PaC thickness that reduces CC without significantly increasing device thickness. We developed multilayer electrocorticography implants with the optimal insulation. They exhibit an in vivo performance comparable to single-layer devices, confirming their suitability for high-quality recordings. Additionally, we demonstrate that depth implants with the same architecture offer alternatives to conventional rigid devices for chronic brain stimulation, thanks to high charge injection capacity and better tissue compliance. We developed intracortical depth implants targeting the rat hippocampus for safe and extended micro-stimulation and recording. Acute in vivo experiments identified parameters for maximal LFP generation in CA1 in response to electrical stimulation of Schaffer collaterals. A 16-day study in freely moving rats demonstrated consistent LFP generation in CA1 in response to axonal stimulation in Stratum Radiatum. Together, our results demonstrate an excellent performance of flexible bioelectronic implants for acute and chronic stimulation and recording, as well as their high potential in neuroscience research.

Charles Rezaei (publication: S. Rezaei-Mazinani) is an Associate Professor and Group Leader in the department of Bioelectronics (BEL) at the Ecole des Mines de Saint-Étienne. He holds a PhD degree in Bioelectronics, during which he worked on the development of organic photodetectors for neuroscience applications. Following his PhD, he completed a postdoctoral fellowship in Alexander Fleischmann's lab at the Center for Interdisciplinary Research in Biology (CIRB) at the Collège de

France. At CIRB, he studied the encoding of odor and spatial information in the mouse piriform and entorhinal cortex. Dr. Rezaei's current research focuses on the use of electronic and optoelectronic materials to design and develop optical and electronic devices for brain interfacing. This includes the design, characterization, and fabrication of high-performance neural implants for stimulation and recording. Additionally, he has a strong interest in neural data analysis.

- **A Battery-Free, High Data-Rate Brain-Machine Interface with RF Backscatter Communication, Wireless Power, and NFC Telemetry**
  Ali Khaleghi – Norwegian University of Science and Technology

In this talk, we present a fully implantable, battery-free Brain-Machine Interface (BMI) that addresses significant challenges in miniaturization, high data-rate wireless communication, and efficient power management. Traditional BMI designs face limitations with power-intensive transceivers and heat generation, hindering long-term functionality. Our approach leverages RF backscatter communication at 434 MHz, enabling 32 Mbps neural data transmission without implant-side transceivers, drastically reducing power demands. Wireless power is delivered through near-field magnetic induction, ensuring continuous functionality within a compact implant. Additionally, NFC telemetry at 13.56 MHz provides secure, bidirectional communication for real-time health monitoring, remote commands, and closed-loop stimulation. This battery-free BMI marks a promising advancement toward durable, efficient neuroprosthetics and seamless brain-computer interaction.

Dr. **Ali Khaleghi**, a distinguished researcher, specializes in electromagnetics, wireless communication, RF systems, and biomedical engineering. With a Ph.D. from the University of Paris XI, he now holds the position of Research Professor at the Norwegian University of Science and Technology (NTNU). Over a 17-year career, his work has significantly advanced the development of wireless implants for applications such as pacemakers, capsule endoscopy systems, brain-machine interfaces, and bio-electromagnetic systems.

He has contributed to numerous high-impact projects, including EU H2020-funded initiatives like B-CRATOS, GLADIATOR, and 5G-HEART, as well as Norwegian Research Council projects such as WINNOW, FORNY Innovation Grant, CIRCLE, and CLIPEUS. His extensive research portfolio includes over 120 peer-reviewed publications and nine patents, marking impactful contributions to implantable technologies and medical diagnostics. As CEO of SalveoSolutions AS, he oversees pioneering developments in battery-free capsule endoscopy implant technology, driving advancements that bridge engineering and healthcare.

SESSION 3 –

PROSPECTS ABOUT THE MACHINE-HUMANS INTERACTIONS

- ### Next-Generation Hand Prostheses: What is next?
  Marco Controzzi – Scuola Superiore Sant'Anna

The human hand, as well as being one of the principal agents of motor activity, is the chief organ of the fifth sense, touch, and part of our communication system. Its anatomical complexity, richness and variety of sensory receptors combined with its intimate communication link with the brain make the replacement of a missing hand by a prosthesis one of the big challenges in rehabilitation engineering. Recent advances in robotics, particularly in understanding task affordances and human manipulation strategies, offer transformative potential for enhancing the symbiosis between humans and prosthetic devices. This speech will explore ongoing research at the Artificial Hands Area of The BioRobotics Institute, integrating robotics advancements and human manipulation insights to develop dexterous prosthetic limbs and advanced human machine interfaces. By translating robotic advancements to prosthetic fields, we aim to foster a successful integration of prostheses with their users, enhancing functionality, and overall usability.

Marco Controzzi is an Associate Professor of Bioengineering at the Biorobotics Institute of the Sant'Anna School of Advanced Studies, where he contributes to the Artificial Hands Area. He holds a BSc and MSc in Mechanical Engineering from the University of Pisa and a PhD in Robotics and ICT from the Sant'Anna School of Advanced Studies. He is also the founder of Prensilia Srl (2009), a company specializing in the commercialization of anthropomorphic hands. His research focuses on the intersection of robotics and neuroscience, with key interests in the design of artificial hands, human-robot interaction, and the study of grasping and manipulation.

- ### Implantable chronic Brain Machine Interface for movement compensation: from clinical proof of concept to use in daily life
  Guillaume Charvet – CEA-Clinatec

Thanks to the WIMAGINE® implants developed by CEA, several clinical trials were initiated by CEA and its partners: CHUGA and EPFL/UNIL/CHUV targeting primarily the validation of the feasibility and the safety but secondly the demonstration of the control of complex effectors for motor or communication assistance or even rehabilitation. To this aim, CEA developed specific algorithms to extract motor intents from motor or somatosensory cortices activity.

In addition, toward home use of BCI system, CEA worked in the miniaturization of the system improving either the wearable part or the algorithms and associated software.
In this presentation, we will come back on 7 years of Machine-Humans Interactions in the framework of clinical trials reporting on user progresses with an evolving BCI set-up.

Guillaume Charvet is currently Head of the neurotechnology biomedical research unit within CEA CLINATEC® in Grenoble (France), with the mission to specify, develop and integrate innovative medical devices in response to medical needs. Its technological research activities are focused on the neuroengineering for neuroprosthesis and neuromodulation devices, particularly in the field of Brain-Computer Interfaces (BCI) with the realization of major clinical demonstrations published in The Lancet Neurology (2019) and Nature (2023). Recently, his team obtained scientific prizes (the international BCI Award 2020 (2nd place), 2022 1st place), 2024 (2nd place), the Leenaards 2021 science prize for biomedical research, CES innovation Award 2024) and several institutional fundings (ANR-SNF project, Horizon Europe EIC projects, MSCA project).

- **Brain-controlled spinal cord stimulation to restore voluntary motor control after paralysis**
  Henri Lorach – EPFL

A spinal cord injury interrupts the communication between the brain and the muscles, leading to paralysis. We restored this communication with a digital bridge between brain and spinal cord to regain voluntary control over the legs and arms. This brain-spine interface (BSI) consists of fully-implanted recording and stimulation systems that establish a direct link between cortical signals and the modulation of epidural electrical stimulation targeting the lumbar and cervical spinal cord respectively. This digital bridge establishes a framework to restore natural control of movement after paralysis and promote neurological recovery.

Henri Lorach is Assistant Prof. at University of Lausanne in Brain Computer Interfaces. He is developing invasive strategies to restore voluntary movements after spinal cord injury and stroke using brain-controlled spinal cord stimulation. Prof. Lorach graduated from Ecole Polytechnique in Paris and completed his PhD at the vision institute working on the encoding of visual information in the retina. He completed postdoctoral training at Stanford University to develop retinal implants that stimulate electrically the retina and restore visual perception to the blind.