



June 23-28 Montpellier, FRANCE

The Joint Annual Meeting of  
The Bioelectromagnetics Society and the  
European BioElectromagnetics Association  
**Technical Program and General Information**



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## Local Organizing Committee



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Co-chairs  
Canada



Isabelle Lagroye  
Co-chairs  
France



Julien Modolo  
Co-chairs  
France



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United Kingdom



Sami Gabriel  
United Kingdom

## From the Co-chairs of the Local Organizing Committee

The **BioEM2019 Local Organizing Committee** welcomes you to **Montpellier, France** for the Joint Annual Meeting of The Bioelectromagnetics Society (BEMS) and the European BioElectromagnetics Association (EBEA).

As the premier international conference in the area of bioelectromagnetics, BioEM2019 is expected to stimulate further research in this field through the exchange of ideas and invigorating discussions, consolidating the state-of-the-art knowledge, and identifying existing gaps.

The BioEM2019 conference is held in the **Corum of Montpellier** which is located in the heart of the city. **Le Corum Conference Center**: A prestigious complex at the heart of the city (10 min walk from the train station. Corum tram stop on 3 lines) in the heart of France's largest pedestrianized area. With its innovative design, this prestigious multi-faceted venue is one of the great facilities that have earned Montpellier its place among the Mediterranean's top business tourism destinations. As well as one of France's top Conference Centers, it also houses the Berlioz Opera House, known for its excellent acoustics and its National Orchestra. The Corum brings two worlds together within one venue - business events for between 50 and 2,000 people and music, both classical and contemporary.

With 440,000 residents, the city of Montpellier distinguishes itself from other European metropolises, with outsider advantages. It is a major place for culture, featuring two opera houses, one of the leading arenas in France, an international dance complex, and one of the country's richest regional fine- arts museums.

With the Mediterranean only 11 km away, the seaside is an integral part of the metropolitan area. The bicycle path sets off from Montpellier along the river Lez and takes you to the coast, beaches such as La Grande Motte, Carnon and Palavas-les-Flots, perfect for the family, the beautiful beaches of Villeneuve-lès-Maguelone, les Aresquiers (Frontignan) or l'Espiguette (Grau du Roi). During April and October, some ephemere private beaches are built all the coastine long, ideal for afterworks and original gala diners. Many water activities such as catamaran, regattas, jetski, canoe, paddle, kitesurf etc.

On the hillsides of the region, grape wine is cultivated since the Antiquity. AOC et countryside wines represent the main part of the production, a wide diversity of vineyards with, for each one, different soils, climates and grape varieties of which the diverse blends make out unique wines with a constantly growing quality. You will love the variety. Wine has been produced all around Montpellier since Antiquity and Languedoc Roussillon is home to a wide variety of wine-growing soils. Most of the local production is composed of AOC and Vins de Pays. There are around a dozen outstanding appellations amongst the Coteaux du Languedoc: Faugères, Saint- Chinian, Pic Saint-Loup, and also the Mireval, Frontignan and Lunel muscats. Don't miss the Grés de Montpellier, grown in Montpellier itself. All part of the local heritage that you will enjoy tasting in the city's best restaurants and bars, in the wine shops or directly at the wineries, as well as in the popular wine bars of Montpellier.

And if you feel like travelling a bit further after the congress, you only need to drive a couple of hours to get to the Pyrenees and 3 to 5 hours for the French riviera or the Alps.

We believe that this will be a fruitful scientific meeting in stimulant and exciting environment in a Mediterranean atmosphere.

**We are delighted to welcome you all at BioEM2019 in Montpellier, France!**

**Alexandre Legros**, LHRI and EuroStim at EuroMov, Univ. of Montpellier, LOC Chair

**Isabelle Lagroye**, EPHE, IMS, Bordeaux, LOC Co-chair

**Julien Modolo**, LTSI, INSERM, Rennes LOC Co-chair

## Technical Program Committee



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Co-chair  
United Kingdom



Micaela Liberti  
Co-chair  
Italy



Meike Mevissen  
Switzerland



Martin Röösl  
Switzerland



Alexandre Legros  
Canada



Maxim Zhadobov  
France

### From the Co-chairs of the Technical Program Committee

Dear Colleague,

On behalf of the Technical Program Committee (TPC), it is our great pleasure to welcome you to the BioEM2019, the annual joint meeting of two societies: the Bioelectromagnetics Society (BEMS) and the European BioElectromagnetics Association (EBEA). BioEM is the largest annual international conference in the field of Bioelectromagnetics bringing together leading scientists from different disciplines to discuss latest achievements and future challenges of the field.

Thanks to contributions from members of both societies, the TPC received record number of proposals for plenaries, tutorials, and workshops, on a wide variety of subjects. This allowed us to put together an exciting and stimulating program covering a wide range of subjects: plenaries on 5G exposure assessment, topicality of IARC evidence for carcinogenicity from RF-EMF, interaction mechanisms, millimeter waves applications, noninvasive stimulation of the nervous system, and one tutorial on body temperature regulation. We are grateful to all invited speakers for accepting our invitation and to workshop organizers for their contribution to the program.

We are also thankful to all of you who have overwhelmed the TPC with the number and quality of the abstracts submitted for BioEM2019. This year, we received 272 papers from 28 countries across the world, 53 of them from students. BioEM conference has a comprehensive and robust reviewing system that involved a board of 103 reviewers, providing at least 5 independent reviews per abstract. The allocation of poster/platform presentation is a complex process depending on availability of sessions, priority of subjects of interest and reviewers scores. Both platform and poster sessions are very well attended, and the authors always get ample opportunities to present their results and have lively and inspiring discussions during the poster sessions, don't miss them!

With a wide range of accepted abstracts, the TPC managed to allocate 14 oral sessions balanced between health protection and biomedical applications, spanning from basic research to standards, from proteins to humans. To give the participants a choice to attend the talks of their interest, sessions are set to cover biological/medical topics in parallel with engineering/physical ones at a given time.

BioEM2019 will also honor colleagues for their contribution to the field. We will have the Chiabrera Lecture for Excellence in Bioelectromagnetics, award from EBEA to outstanding early stage researcher, the Arthur Pilla young scientist award, and the d'Arsonval Lecture, award from BEMS to senior scientist as recognition of outstanding career. The authors of the most influential BEM journal paper for 2019 will be recognised and we will close the BioEM2019 with the traditional awards for the best student presentations (poster and platform).

We hope that BioEM2019 will provide a multidisciplinary and interdisciplinary forum to exchange ideas, and share knowledge. This conference is a unique opportunity to bridge the gaps and establish networks in the field of Bioelectromagnetics.

Our special thanks are due to members of TPC, for their dedication and hard work, the Local Organizing Committee for their efforts in accommodating the program and organizing special moments together, the sponsors for their help and support in realizing all this at the best, and last but not least, the Lawson Institute for their hard work in providing IT services.

We hope you have an enjoyable experience in Montpellier!

Micaela Liberti and Azadeh Peyman (BioEM2019 TPC Co-chairs)

# Technical Program Review Committee



Francesca Apollonio  
Italy



De ia Arnaud-Cormos  
France



Quirino Balzano  
United States



Frank Barnes  
United States



Barbara Benassi  
Italy



Laura Birks  
Spain



Carl Blackman  
United States



Christian Bornkessel  
Germany



Kerry A. Broom  
United Kingdom



Myles Capstick  
Switzerland



Maura Casciola  
Italy



Antonino Mario Cassara  
Switzerland



Astrid Chamson-Reig  
Canada



Guangdi Chen  
China



C-K. Chou  
United States



Michal Cifra  
Czech Republic



Robert Cleveland  
United States



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Italy



Annalisa De Angelis  
Italy



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New Zealand



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China



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Belgium



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Poland



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Finland



Bor Kos  
Slovenia



Susanna Lagorio  
Italy



Isabelle Lagroye  
France



Alireza Lajevardipour  
Australia



Ae-kyoung Lee  
Korea



Hae-June Lee  
Korea



Micaela Liberti  
Italy



James C. Lin  
United States



Ilaria Liorni  
Switzerland



Mai Lu  
China



Isabelle Magne  
France



Andrew Marino  
United States



Carmela Marino  
Italy



Luc Martens  
Belgium



Robert McIntosh  
Australia



Caterina Merla  
Italy



Meike Mevissen  
Switzerland



Simona Miclaus  
Romania



Julien Modolo  
France



Mihaela Morega  
Romania



Manuel Murbach  
Switzerland



Denys Nikolayev  
France



Richard Nuccitelli  
United States



Alberto Nájera  
Spain



Chiyoji Ohkubo  
Japan



Hideyuki Okano  
Japan



Teruo Onishi  
Japan



Alessandra Paffi  
Italy



Andrei Pakhomov  
United States



Olga Pakhomova  
United States



Weidong Pan  
China



Anne Perrin  
France



Azadeh Peyman  
United Kingdom



Rosanna Pinto  
Italy



Claudio Pioli  
Italy



Blanka Pophof  
Germany



Christopher Portier  
Switzerland



Florence Poulletier De Gannes  
France



Frank Prato  
Canada



Alan Preece  
United Kingdom



Mary Redmayne  
New Zealand



Jack Rowley  
Australia



Martin Röösi  
Switzerland



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Japan



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Croatia



Gernot Schmid  
Austria



Tsukasa Shigemitsu  
Japan



Tao Song  
China



R. James Swanson  
United States



Richard Tell  
United States



Shoogo Ueno  
Japan



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Netherlands



Jianqing Wang  
Japan



Jonna Wilen  
Sweden



Andrew Wood  
Australia



Sachiko Yamaguchi-Sekino  
Japan



Kenichi Yamazaki  
Japan



Shengyong Yin  
China



Olga Zeni  
Italy



Maxim Zhadobov  
France

Elena della Valle  
Italy

## Schedule at a Glance

### Sunday, June 23, 2019

Time	Session	Name	Location
09:00 - 12:30	M1	BEMS Board Meeting	Joffre 4
09:00 - 12:30	M2	EBEA Council Meeting	Joffre 5
14:00 - 17:00	PW	Pre Conference Workshop - Theory and hands-on practical for transcranial Direct Current Stimulation (tDCS) and transcranial Alternating Current Stimulation (tACS)	Barthez
18:30 - 21:30		Welcome Reception	Joffre 1

### Monday, June 24, 2019

Time	Session	Name	Location
09:00 - 09:30		Welcome	Einstein
09:30 - 10:30	P1	Plenary 1 - Non invasive electrical brain stimulation	Einstein
10:30 - 11:00		Coffee Break	Joffre 2-3
11:00 - 12:30	S01	Electric and magnetic stimulation of the nervous system	Einstein
11:00 - 12:30	S02	Cellular effects of radiofrequency fields and millimeter waves	Barthez
12:30 - 14:00		Lunch	Joffre 1
14:00 - 15:00	FA	Student Flash Poster Session A	Einstein
15:00 - 16:30	PA	Poster Session A	Joffre 2-3
16:30 - 17:00		Coffee Break	Joffre 2-3
17:00 - 18:30	S03	Numerical dosimetry of RF fields	Einstein
17:00 - 18:30	S04	Effects of electromagnetic fields (in-vivo)	Barthez
19:30 - 22:00		Student Ice Breaker	Le Clandestin piano-bar

**Tuesday, June 25, 2019**

<b>Time</b>	<b>Session</b>	<b>Name</b>	<b>Location</b>
08:30 - 09:30	P2	Plenary 2 - Has evidence for carcinogenicity of RF-EMF changed since IARC's assessment?	Einstein
09:30 - 10:00		Coffee Break	Joffre 2-3
10:00 - 11:00	CA	Chiabrera Award	Einstein
11:00 - 12:30	S05	Epidemiological Studies	Barthez
11:00 - 12:30	S06	Human Studies	Einstein
12:30 - 14:00		Lunch	Joffre 1
13:00 - 14:00	M3	EBEA Assembly	Barthez
14:00 - 15:00	FB	Student Flash Poster Session B	Einstein
15:00 - 16:30	PB	Poster Session B	Joffre 2-3
16:30 - 17:00		Coffee Break	Joffre 2-3
17:00 - 18:30	W1	Workshop 1 - Atmospheric electromagnetic field bioeffects	Barthez
17:00 - 18:30	W2	Workshop 2 - Differences of exposure limits between the new ICNIRP Guidelines and IEEE C95.1 Standard	Einstein
19:00 - 23:00		Conference Dinner	Domaine des Moures

**Wednesday, June 26, 2019**

<b>Time</b>	<b>Session</b>	<b>Name</b>	<b>Location</b>
09:00 - 10:30	P3	Plenary 3 - 5G real-life exposure: how to assess and optimize?	Einstein
10:30 - 11:00		Coffee Break	Joffre 2-3
11:00 - 12:00	T1	Tutorial 1 - Body temperature regulation in Mammals	Einstein
12:00 - 13:00	S07	Risk, Safety Standards & Policy	Einstein

12:00 - 13:00	S08	Effects of ELF magnetic fields (in-vitro)	Barthez
13:00		Lunch (not provided)	

**Thursday, June 27, 2019**

<b>Time</b>	<b>Session</b>	<b>Name</b>	<b>Location</b>
09:00 - 10:00	DA	d'Arsonval Award	Einstein
10:00 - 11:30	S09	Exposure assessment techniques I	Barthez
10:00 - 11:30	S10	Interaction Mechanisms (theoretical and experimental)	Einstein
11:30 - 12:00		Coffee Break	Joffre 2-3
12:00 - 13:00	P4	Plenary 4 - Can membrane proteins act as biological probes for EM fields?	Einstein
13:00 - 14:30		Lunch	Joffre 1
13:30 - 14:30	M4	BEMS Assembly	Barthez
14:30 - 16:00	S11	Dosimetry of ELF/LF fields	Einstein
14:30 - 16:00	S12	Electroporation Studies and Effects of Pulsed Electric Fields	Barthez
16:00 - 16:30		Coffee Break	Joffre 2-3
16:30 - 18:00	W3	Workshop 3 - Dosimetric aspects in exposure assessment to wireless power transfer systems	Einstein
16:30 - 18:30	W4	Workshop 4 - Toward an innovative use of ultrashort electric pulses in medicine: From biological effects to therapeutic applications	Barthez

**Friday, June 28, 2019**

<b>Time</b>	<b>Session</b>	<b>Name</b>	<b>Location</b>
09:00 - 10:30	S13	Exposure assessment techniques II	Barthez
09:00 - 10:30	S14	Emerging and Future Biomedical Applications	Einstein

10:30 - 11:00		Coffee Break	Joffre 2-3
11:00 - 12:00	P5	Plenary 5 - Millimeter- and submillimeter-wave applications in biology and medicine: Potential and challenges	Einstein
12:00 - 13:00	SA	Awards Session	Einstein
13:00 - 13:30		Closing Ceremony	Einstein
15:00 - 18:00	M5	BEMS Board Meeting	Joffre 4
15:00 - 18:00	M6	EBEA Council Meeting	Joffre 5

## General Information

### THE CONFERENCE VENUE

BioEM2019 will be held in the **Corum Conference Center**, a prestigious complex at the heart of **Montpellier** (10 minute walk from the train station) in the heart of France's largest pedestrianized area. With its innovative design, this prestigious multi-faceted venue is one of the great facilities that have earned Montpellier its place among the Mediterranean's top business tourism destinations.

**Montpellier** is the 7<sup>th</sup> largest city of France, and the fastest growing city over the last 25 years. Rich in character, and located at the crossroads of Europe, its creativity, effervescence and dynamism have contributed to the international visibility of Montpellier. Montpellier is also a city of medicine, and is also at the cutting edge of research activities and the digital economy. It offers all the facilities required for high profile national and international events and all types of business meetings, always with a promise of excellence.

**Montpellier** benefits from a Mediterranean climate with hot, dry summers, and the temperature in June (at the time of the conference) is typically between 16 and 26 degrees Celsius.

### REGISTRATION AND INFORMATION DESK

When you enter the conference venue through the main entrance of the Corum on level 1, signs will guide you to the Registration and Information desk located at the entrance of the room Joffre 1.

On Sunday, June 23, the Registration Desk will be open from 13:30.

From Monday, June 24 until Friday, June 28, the Registration Desk will be open from 8:00 until the end of the last meeting session of each day.

### CONFERENCE BADGE

Badges must be worn at all times during the meeting and during all social events (registered guests as well). The badges will be delivered at the Registration desk and will include the WIFI information.

### CONFERENCE LUNCH AND COFFEE BREAKS

A buffet lunch will be provided in Joffre 1 on Monday June 24, on Tuesday June 25, and on Thursday June 27 but NOT on Wednesday June 26.

Coffee breaks will take place in the morning and in the afternoons in Joffre 2-3 near the posters.

### SOCIAL EVENTS

#### 1. GENERAL INFORMATION

The Corum of Montpellier is located downtown Montpellier and you are less than 5-min walk from the Place de la Comédie, which is the main place of the city, in the center of one of the biggest urban walking areas in France. From there you can access the infinity of old charming little streets and places and enjoy shopping, bars and restaurants. There is also a lot inside or outside visits you can make, and you'll be provided in your conference bag with a map of the city and a book detailing many activities and visits you could select from.

#### 2. WELCOME RECEPTION, Sunday June 23

Sunday, June 23, 18:30 at the conference venue (Corum room Joffre 1). Expected end time: approximately 21:30.

### 3. STUDENT ICE BREAKER, Monday June 24

The Student Ice Breaker will be held on Monday June 24 at the piano-bar Le Clandestin (18 Rue de la Valfere, 34000 Montpellier). This will be a great occasion to get to know each other sharing tapas and a few drinks while performing at the blind test lead by the pianist! Let's get to the bar starting at 19:30 for a blind test (in teams) starting at 20:00.

### 4. CONFERENCE DINNER, Tuesday June 25.

Please join us Tuesday June 25, 18:30 for the Conference dinner. We will leave from the Corum by bus for the Domaine de Moures (Chemin des Moures - 34750 VILLENEUVE LÈS MAGUELONE), a site with 1.5 km of salted lake shore surrounded by wheat fields as far as you can see and its own 18th century chapel.

**Please make sure to be ready at the Corum starting at 18:30 for the first bus**, the last bus is scheduled to leave at 18:50. 20 to 30 minutes later you'll arrive at the Domaine des Moures and begin with a cocktail before having the Gala dinner served in this magic environment. Of course you will need your dancing shoes on to properly end the night!

### 5. TOURISTIC SUGGESTIONS for the free afternoon on Wednesday June 25

The LOC recommends some touristic activities in Montpellier and its surroundings. Although just walking through the city with your touristic map and discovering the Arc de Triumph, the Peyrou garden or the Botanic garden, seeing cathedrals St Roch and St Anne, stopping for a drink Place Jean Jaures or Place de la Canourgue may already fill your free time, below is a list of suggestions you may be interested in.

- You could for example be interested in a guided tour of the historical center of Montpellier (<https://book.montpellier-france.com/en/event/a1133667/visit-montpellier-guided-city-tour-in-english-historical-c/showdetails>)
- Or a bus city tour: <https://www.montpellier-tourisme.fr/offre/fiche/montpellier-city-tour/LOILAR034V50FM3B>
- Or a little train city tour: <https://www.montpellier-france.com/offre/fiche/le-petit-train-de-montpellier/LOILAR034FS0014L>
- Why not book a guided tour of the medicine university, that is the oldest one worldwide still in activity (13<sup>th</sup> century), and in particular of the famous « Conservatoire d'anatomie » (Anatomy Museum, <https://www.umontpellier.fr/patrimoine/musees/musee-danatomie>)
- You could also visit the famous Fabre art museum (<http://museefabre-en.montpellier3m.fr>)
- Or the Pavillon Populaire if you like photography (<https://www.montpellier.fr/506-les-expos-du-pavillon-populaire-a-montpellier.htm>)
- Or maybe some wine tasting would suit you better: <https://www.montpellier-france.com/offre/fiche/montpellier-wine-tours/ORGLAR034V50FLC8>

If you are more adventurous and you want to explore a bit further the surrounding:

- On the sea side is Villeneuve-Les-Maguelone (<https://www.montpellier-france.com/Prepare-Book/Discoveries/Montpellier-metropole/Villeneuve-les-Maguelone>) and its Cathedral: <https://www.sitesdexception.fr/sites/maguelone-cathedral/?lang=en>
- If you want to head towards St. Guilhem-Le-Désert (<https://www.saintguilhem-valleeherault.fr>), you can stop to the pont du Diable (<https://www.montpellier-france.com/offre/fiche//PNALAR0340000029>) or Clamouse Cave (<https://www.clamouse.com/en/home/>)
- Aigues-Morte is also a nice half day option (<https://www.montpellier-france.com/Prepare-Book/Discoveries/In-the-region/Historic-cities-and-towns/Aigues-Mortes>)
- If you are more a beach person, we would recommend that you head to a "Paillote" on the beach of the Grand Travers such as la Paillote Bambou (<https://www.lapaillotebambou.com>) or l'Effet Mer (<http://www.effetmer.com>), or from Maguelone such as for example Le Carré Mer (<https://www.carre-mer.fr>).

If you need a taxi, a good way to go: <http://www.taxibleudumidi.fr/?lang=2>

For more, you will have a touristic book in your conference bag that will prove helpful. Also, more can be found here: <https://www.montpellier-france.com>

## ORAL AND POSTER PRESENTATION GUIDELINES

Please find below some potentially useful material to assist you in preparing a presentation for BioEM2019.

Papers are to be presented in two basic formats: Oral and Poster Presentations. Below you will find specific information concerning these two formats.

If for any reason you find yourself unable to personally present your paper, please try to arrange for someone else to present it. **If nobody is available to present your work, you must notify the TPC Chairs well ahead of time (at [tpc@bioem.org](mailto:tpc@bioem.org)). If the presentation does not take place, the corresponding abstract will be removed from the online abstract book.**

**NO PHOTOS ARE ALLOWED DURING THESE PRESENTATIONS**

### Oral Presentations

All oral presentations have been allocated a 15-minute time slot. These 15-minutes must include the presentation, questions, and transitioning to the next speaker. It is recommended that speakers plan on a 12 minute presentation to allow for questions and discussion (3 minutes). It is important to strictly adhere to this schedule as most oral presentations are scheduled in parallel sessions. Arrive at least 10 minutes early prior to the start of the session and introduce yourself to the chair and familiarize yourself with the audio-visual equipment.

Each meeting room will be equipped with a personal computer to accommodate PowerPoint and PDF presentation formats. Technical support will be present in each meeting room to ensure flawless execution. Authors must upload their presentations onto the designated computer at the conference venue during the break before their session at the latest. Presenters will not be allowed to connect their own computer to the projection system. Presentations can be loaded via USB flash memory stick. Authors are urged to try to minimise any potential problems by taking advantage of redundancy whenever possible: save and bring presentations in multiple formats (PowerPoint and Adobe PDF), store presentations in more than one media, and keep the media on your person during travel.

The best student oral presentation(s) will be awarded.

All oral presenters are expected to support their presentation with a corresponding slideshow.

The slides should be prepared in either PowerPoint (PPT/PPTX) or PDF format to ensure maximum compatibility with the equipment available on-site. Videos should either be embedded into the slides, or, if linked, physically accompany the main presentation document.

**There will be a designated contact person coordinating the upload of your file in your session room. Please coordinate with this person to upload your presentation preferably the day before.**

Presenters are strongly encouraged to verify that their presentation materials uploaded properly on the on-site equipment.

### Poster Presentations

Poster sessions are an important part of the BioEM2019 conference and a method for immediate and effective communication between all those interested in specific subjects, actions or programs. Posters should be carefully designed and prepared to ensure their full impact.

Two poster sessions, i.e., A on Monday, June 24 at 15:00, and B on Tuesday, June 25 at 15:00, are planned in Joffre 2-3 meeting room (Level 1).

The poster presenters are kindly requested to follow the instructions below:

Double-sided boards in portrait format (120 cm x 100 cm), will be available for each author to attach their poster to and authors are advised to limit their poster size to 120 cm (height) X 90 cm (width) – this includes format A0. Material will be provided by the organizers for mounting posters. The boards will be numbered to correspond with poster numbers in the Program and student posters will be clearly

identified.

**Authors should be present at their stations for the duration of their assigned session to discuss their work and answer questions, as there will be a flux of attendees.**

Mounting: Posters can be mounted from 16:00 on Sunday June 23.

Each board will be marked with the poster number, as indicated in the final program.

Removal: Posters must be removed before 18:00 on Thursday June 27.

## **Student Poster Presentations with Flash Presentation**

All student posters will also be presented as poster flash presentation. The two poster flash sessions will take place in Einstein meeting room (Level 0) on Monday, June 24 from 14:00 to 15:00 (FA), and on Tuesday, June 25 from 14:00 to 15:00 (FB).

Please ensure that you plan your communication carefully. The language is English.

Each presenter will have a 3 minutes time to present 4 slides maximum for the flash presentation (discussions will follow afterwards at your poster). Please introduce yourself in the beginning of your presentation and point out the main findings of your work. Hence your presentation should not include new material that is not shown on your poster.

The Chairs will call up the next presenter after the 3 min are over and you have to leave the podium.

Please upload your presentation at the computer available in the Einstein room on Monday, June 24 before 13:30 for the FA session, and on Tuesday June 25 before 13:30 for the FB session either in PowerPoint (PPT/PPTX) or PDF format, since all flash poster presentations will be uploaded beforehand on the same computer. The presenters will not be allowed to use their USB memory sticks or laptops during the session.

The best student poster(s) will be awarded.

## CONFERENCE ORGANIZERS

### Conference Organizing and Service, Events Planning, Registration and Accommodation Arrangement, Meeting Website Maintenance

Alexandre Legros,  
LOC Chair

Lawson Health Research  
Institute  
268 Grosvenor street  
London, ON, Canada



EuroStim and EuroMov  
700 Avenue du Pic St Loup  
34090 Montpellier, France



Isabelle Lagroye,  
LOC Co-chair

EPHE, UMR 5218  
Laboratoire de l'Intégration,  
du Matériau au  
Système (IMS)  
Bordeaux, France



Julien Modolo,  
LOC Co-chair

INSERM U1099  
Laboratoire de Traitement  
du Signal et de l'Image  
(LTSI)  
Rennes, France



In addition, Sud Congrès Conseil was hired in order to assist with all the conference organizing matter:

162 cours du Marechal Galliéni  
33400 Talence, France



### Lawson Health Research Institute BioEM Website, Communication and Meeting Support

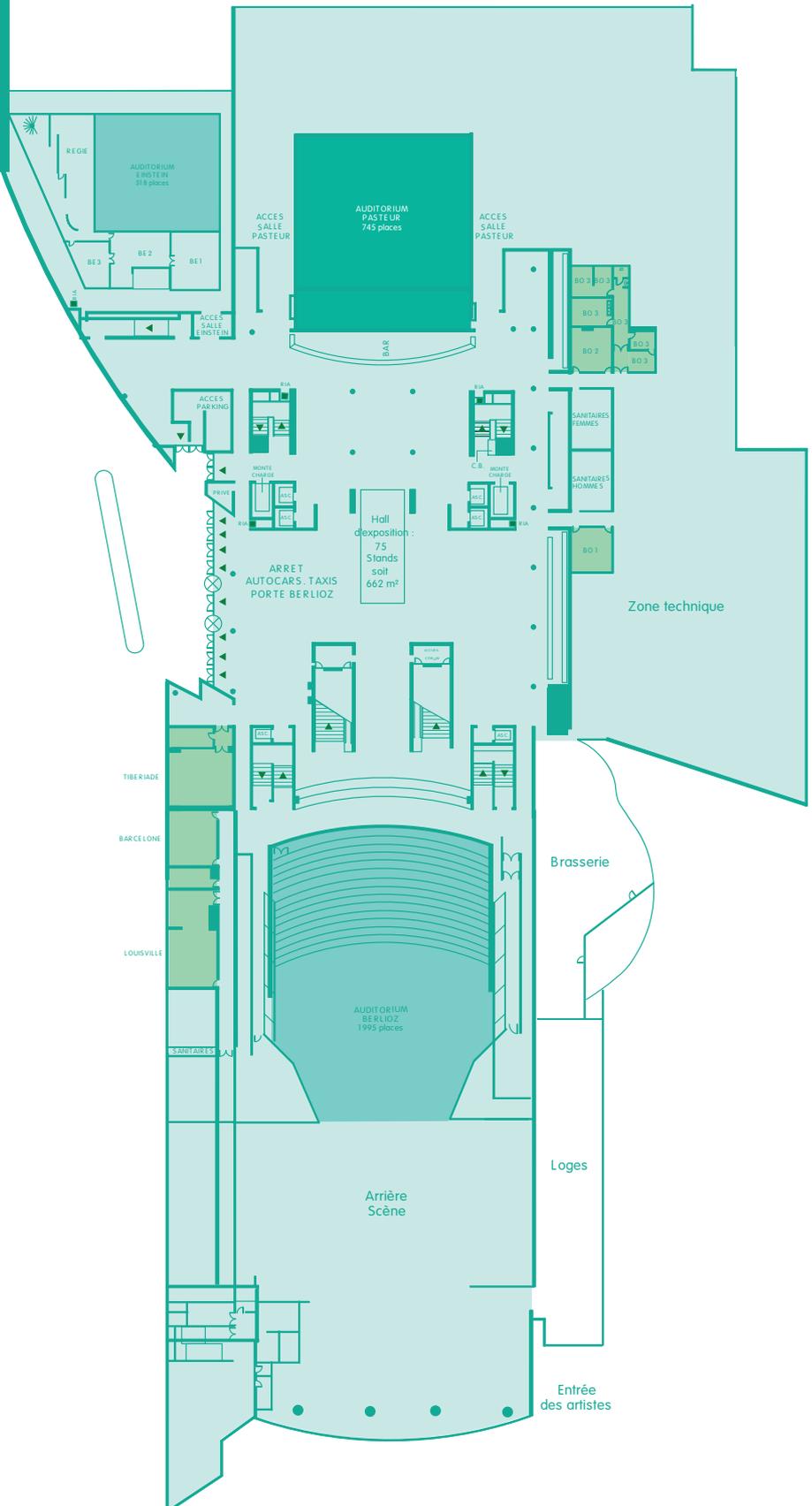
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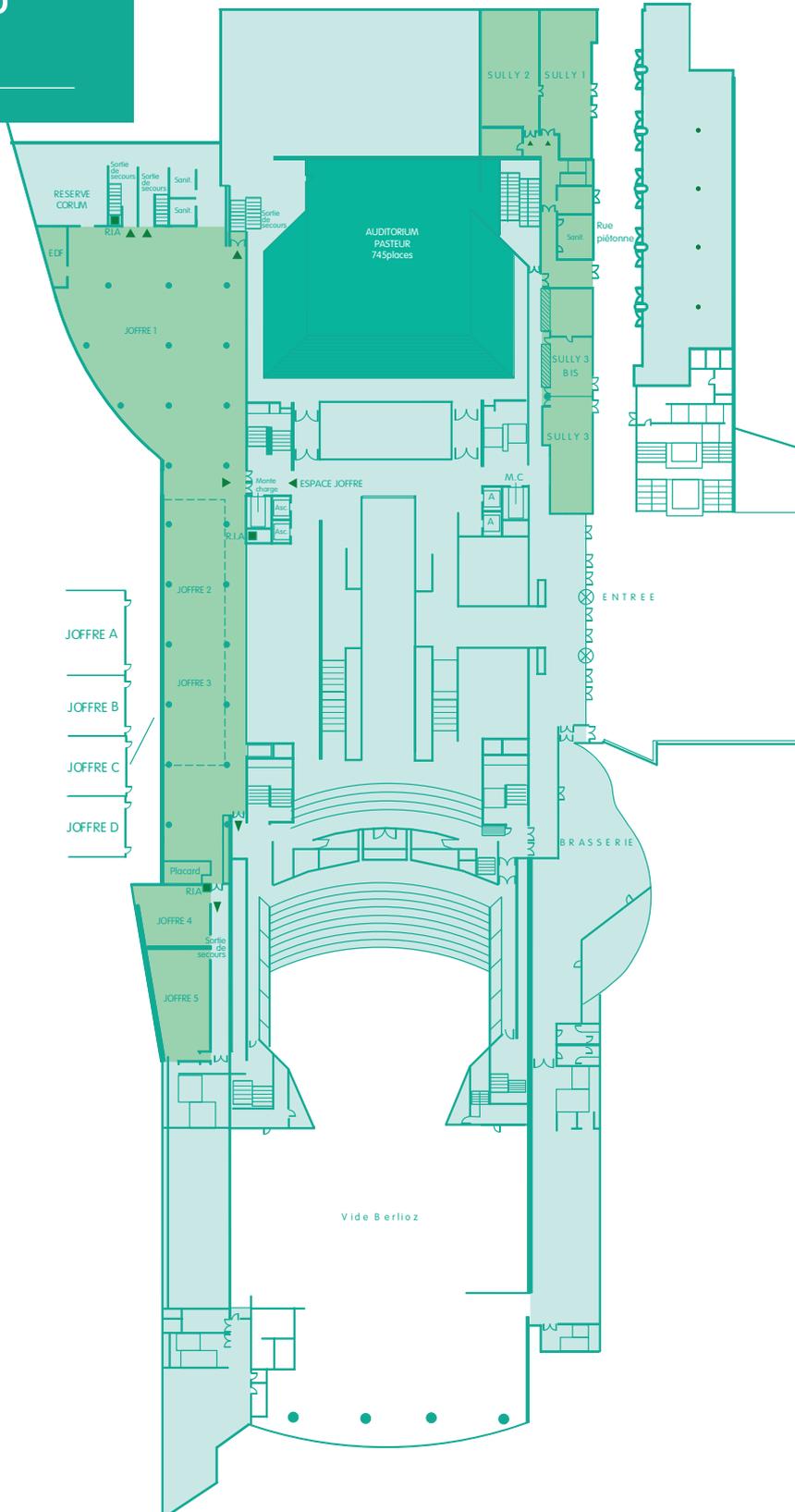
Lawson Health Research Institute  
268 Grosvenor Street  
London, Ontario,  
Canada, N6A-4V2  
office@bioem.org  
office@bems.org



# Niveau 0



# Niveau 1





# Technical Program

**Sunday June 23, 2019**

**Session: M1  
BEMS Board Meeting  
Sunday June 23, 2019 • 09:00 - 12:30  
Joffre 4**

**Session: M2  
EBEA Council Meeting  
Sunday June 23, 2019 • 09:00 - 12:30  
Joffre 5**

**Session: PW  
Pre Conference Workshop - Theory and hands-on practical for transcranial Direct Current Stimulation (tDCS) and transcranial Alternating Current Stimulation (tACS)  
Sunday June 23, 2019 • 14:00 - 17:00  
Barthez  
Chairs: Marom Bikson & Bruno Vandelanotte**

**PW-1 [14:00]**

## **Workshop instructors and Schedule**

Marom Bikson<sup>1</sup> & Bruno Vandelanotte<sup>2</sup>

<sup>1</sup>*The City College of New York, New York, NY, USA, 10031*

<sup>2</sup>*Vandelanotte Consulting, Brugge, Belgium, B-8200*

This workshop is open to participants of all backgrounds interested in a broad introduction to the principles and applications of tDCS and tACS. The theory portion will introduce basic concepts in dosing such as anode/cathode, electrode portion, current intensity, and frequency. The hands-on portion will allow participants to practice application of tDCS/tACS including using conventional electrodes and High-Definition electrodes. Advanced technique to ensure outcome reproducibility and tolerability will be explained. How to apply tDCS/tACS in home settings and how to integrates with brain imaging (EEG) will also be introduced. All participants will be provided workshop slide handouts, a certificate of attendance, and electrodes.

## **Schedule**

- Introductory remarks [Bikson and Vandelanotte]
- tDCS – Principles and mechanisms [Bikson]
- Stimulation parameters and protocols [Bikson]
- Safety [Bikson]
- Clinical implementation & hands-on practical exercises [Bikson and Vandelanotte]
- Professional standards and recap [Bikson and Vandelanotte]

**Welcome Reception  
Sunday June 23, 2019 • 18:30 - 21:30  
Joffre 1**

**Monday June 24, 2019**

**Welcome**  
**Monday June 24, 2019 • 09:00 - 09:30**  
**Einstein**

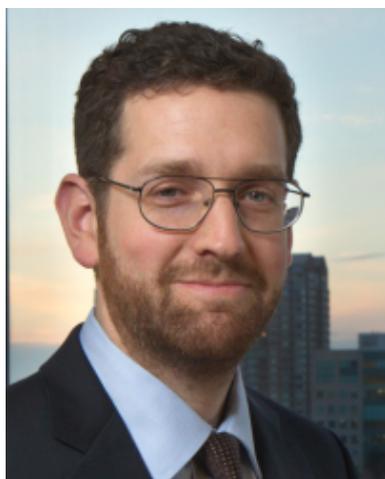
**Session: P1**  
**Plenary 1 - Non invasive electrical brain stimulation**  
**Monday June 24, 2019 • 09:30 - 10:30**  
**Einstein**  
**Chairs: Alexandre Legros & Azadeh Peyman**

**P1-1 [09:30]**

**Electrical brain stimulation**

Marom Bikson<sup>1</sup>

<sup>1</sup>*The City College of New York, New York, NY, USA, 10031*



**Biographical sketch**

Marom Bikson is the Shame Professor of Biomedical Engineering at The City College of New York. He is known for his work on the cellular mechanisms of electrical stimulation and translational medical device design. Dr. Bikson group focuses on electrical stimulation devices for neurological and psychiatric disorders. He has published over 250 articles on medical device technology and brain stimulation. Technologies invented in Dr. Bikson's lab are in hundreds of medical centers globally.

**Abstract**

Non-invasive electrical brain stimulation with low intensity currents are now broadly investigated for their therapeutic potency in clinical populations and modulation of cognition in health individuals. Among these interventions, transcranial Direct Current Stimulation (tDCS) is the most broadly and intensively investigated as well as transcranial Alternating Current Stimulation (tACS). During tDCS and tACS low-amplitude (few mA) current is applied for tens of minutes to the brain through electrodes on the scalp. For tDCS the waveform is a sustained current while for tACS the waveform is sinusoidal of typically low (<100 Hz) frequency, though higher frequencies (>1 kHz) are also explored. tDCS and tACS are well tolerated producing only mild transient skin irritation and are considered safe enough to test even in healthy individuals. tDCS and tACS produce static and oscillating, respectively, electric fields in the brain of <1 V/m amplitude. tDCS and tACS can produce immediate acute changes in brain excitability and, especially when applied in repeated sessions, long term changes in brain function. The therapeutic applications of tDCS and tACS include depression, chronic pain, multiple sclerosis, movement disorders (Parkinson's), schizophrenia, rehabilitation following injury, attention-deficit hyperactivity disorder (ADHS), post-traumatic stress disorder (PTSD) and various forms of addiction. In health individuals tDCS and tACS have been tested to enhance learning, working memory, creativity, and sports performance. Summarizing decades research and highlighting emerging concepts, this talk addresses four closely related questions. How do the low intensity electric fields produced by tACS and tDCS modulate complex brain functions? What the cellular mechanisms of tDCS and tACS? How are so many different application of tDCS and tACS possible? Are there legitimate concerns about long-term side-effects of tDCS and tACS exposure?

**P1-2 [10:00]**

**Non invasive deep brain stimulation via delivery of temporally interfering electric fields**

Nir Grossman<sup>1</sup>

<sup>1</sup>*Imperial College London, London, United Kingdom*

**Biographical sketch**

Nir is an assistant professor at Imperial College London and a founding fellow of the UK Dementia Research Institute. The long-term goal of his research is to develop neuromodulatory interventions for brain disorders by direct control of the aberrant neural activity. Nir received a BSc in physics from the Israeli Institute of Technology (Technion), an MSc in electromagnetic engineering from the Technical University of Hamburg-Harburg, and a PhD in neuroscience from Imperial College London. He then completed a postdoc training, as a Wellcome Trust Fellow, at the Massachusetts Institute of Technology (MIT) and Harvard University. Nir was recently awarded the 2018 Science & PINS Prize for Neuromodulation for describing how temporal interfering of electric fields can stimulate deep brain structures non-invasively.



### Abstract

Electrical brain stimulation is a key technique in research and clinical neuroscience studies, and also is in increasingly widespread use from a therapeutic standpoint. However, to date all methods of electrical stimulation of the brain either require surgery to implant an electrode at a defined site, or involve the application of non-focal electric fields to large fractions of the brain. We report a noninvasive strategy for electrically stimulating neurons at depth. By delivering to the brain multiple electric fields at frequencies too high to recruit neural firing, but which differ by a frequency within the dynamic range of neural firing, we can electrically stimulate neurons throughout a region where interference between the multiple fields results in a prominent electric field envelope modulated at the difference frequency. We validated this temporal interference (TI) concept via modeling and physics experiments, and verified that neurons in the living mouse brain could follow the electric field envelope. We

demonstrate the utility of TI stimulation by stimulating neurons in the hippocampus of living mice without recruiting neurons of the overlying cortex. Finally, we show that by altering the currents delivered to a set of immobile electrodes, we can steerably evoke different motor patterns in living mice.

**Coffee Break**  
**Monday June 24, 2019 • 10:30 - 11:00**  
**Joffre 2-3**

**Session: S01**  
**Electric and magnetic stimulation of the nervous system**  
**Monday June 24, 2019 • 11:00 - 12:30**  
**Einstein**  
**Chairs: Julien Modolo & Heidi Danker-Hopfe**

**Session: S02**  
**Cellular effects of radiofrequency fields and millimeter waves**  
**Monday June 24, 2019 • 11:00 - 12:30**  
**Barthez**  
**Chairs: Claudia Consales & Isabelle Lagroye**

#### S01-1 [11:00]

##### **Dosimetric analysis on the pain matrix exposed to low-intensity extremely low-frequency magnetic fields**

Martina Galli<sup>1</sup>, Micol Colella<sup>1</sup>, Alessandra Paffi<sup>1</sup>, Alex Thomas<sup>2</sup>, Francesca Apollonio<sup>1</sup>, Frank S. Prato<sup>2</sup> & Micaela Liberti<sup>1</sup>

<sup>1</sup>*Department of Information Engineering, Electronics and Telecommunications (DIET), University of Rome "La Sapienza", Rome, Italy, 00184*

<sup>2</sup>*Lawson Health Research Institute, London, Ontario, Canada, N6C 2R5*

**Keywords: Dosimetry (computational), ELF/LF, Completed (unpublished)**

#### S02-1 [11:00]

##### **STUDENT PAPER**

##### **Do radiofrequency electromagnetic fields (RF-EMF) alter neuronal differentiation and mitochondrial function?**

Nicole von Niederhäusern<sup>1</sup>, Angélique Ducray<sup>1</sup>, Manuel Murbach<sup>2</sup> & Meike Mevissen<sup>1</sup>

<sup>1</sup>*Division of Veterinary Pharmacology & Toxicology, University of Bern, Bern, Switzerland, 3012*

<sup>2</sup>*IT'IS Foundation, Zurich, Switzerland, 8004*

**Keywords: In vitro, RF/Microwaves, Work in Progress**

**Presented by: Nicole von Niederhäusern**

A number of studies addressed the possible relationship between radiofrequency

**Presented by: Alessandra Paffi**

A realistic 3D model of the cortical areas deputed to the pain processing, i.e. Pain Matrix, has been developed. The model of the Pain Matrix has been inserted inside the human head model Duke (ViP, v1) with the aim to carry out a comparative dosimetric analysis on such areas when exposed to the complex neuroelectromagnetic pulse (CNP) by means of two exposure systems used in studies on volunteers: a Z-gradient coil system and a suitably designed headset. Results show that the two systems induce very different exposure conditions, in terms of both magnetic induction field B and electric field E, thus feeding conditions of the two stimulators should be properly adjusted in order for them to elicit similar effects.

**S01-2 [11:15]**

**Extremely low-frequency magnetic fields as neuroprotective treatment in acute ischemic stroke: models, mechanisms and clinical application**

Fioravante Capone<sup>1</sup>, Micol Colella<sup>2</sup>, Francesco Motolese<sup>1</sup>, Maria Grazia Rossi<sup>1</sup>, Francesca Camera<sup>2</sup>, Francesca Apollonio<sup>2</sup>, Vincenzo Di Lazzaro<sup>1</sup> & Micaela Liberti<sup>2</sup>

<sup>1</sup>*Unit of Neurology, Neurophysiology, Neurobiology, Department of Medicine, Università Campus Bio-Medico, Rome, Italy, 00128*

<sup>2</sup>*Department of Information Engineering, Electronics and Telecommunication (DIET), University of Rome "La Sapienza", Rome, Italy*

**Keywords: Human, ELF/LF, Completed (unpublished)**

**Presented by: Fioravante Capone**

Extremely low frequency magnetic fields (ELF-MF) could be an alternative neuroprotective treatment for stroke because preclinical studies demonstrated their effects on the mechanisms underlying ischemia. Preliminary data showed the safety and tolerability of the ELF-MF in patients. However, the mechanisms of action are still unclear. Dosimetry can describe electrical and magnetic quantities induced in brain and biophysical models can simulate how ELF-MF interact with neurons. Neurophysiology represents the main tool to explore, in vivo, ELF-MF effects. Here, we describe the potentialities of such multidisciplinary approach to gain new insights into experimental data, and to test novel hypotheses regarding mechanisms of actions of ELF-MF.

electromagnetic field (RF-EMF) exposure and neurodegenerative diseases. During neuronal differentiation, cells undergo major changes including a metabolic switch from glycolysis to oxidative phosphorylation and underlying signaling pathways. The aim of our study was to evaluate the impact of RF-EMF exposure before and during neuronal differentiation using an in vitro model. Our data show that RF-EMF did not alter the neuronal differentiation into dopaminergic and cholinergic phenotypes nor their underlying signaling pathways and mitochondrial function and fusion.

**S02-2 [11:15]**

**Real-time study of the effects of radiofrequency fields at the cellular and molecular levels: the results of the Geronimo project**

Emmanuelle Poque-Haro<sup>1</sup>, Hermanus Ruigrok<sup>1</sup>, Delia Arnaud-Cormos<sup>2</sup>, Rémy Renom<sup>1</sup>, Annabelle Hurtier<sup>1</sup>, Florence Poulletier De Gannes<sup>1</sup>, Isabelle Lagroye<sup>1</sup>, Bernard Veyret<sup>1</sup>, Philippe Leveque<sup>2</sup> & Yann Percherancier<sup>1</sup>

<sup>1</sup>*Laboratoire de l'Intégration du Matériau au Système, CNRS UMR 5218, Talence, France, 33400*

<sup>2</sup>*XLIM, CNRS UMR 7252, Limoges, France, 87000*

**Keywords: In vitro, RF/Microwaves, Completed (unpublished)**

**Presented by: Yann Percherancier**

Within the Geronimo European project, we used cellular impedance and molecular probes based on the Bioluminescence Resonance Energy Transfer technique (BRET) to assess the real-time cellular and molecular effects of 1800 MHz radiofrequency fields, continuous wave (CW) or modulated with environmental signals (up to 6 W/kg for BRET experiments and 25 W/kg for cellular impedance), in live cells. We found that radiofrequency field exposure (i) altered neither basal level of HSF-1 and RAS/ERK stress response pathways nor the potency or the efficacy of chemicals to activate these molecular pathways, and (ii) did not modify primary rat astrocytes and neurons global cell behavior and their response to a chemical pollutant.

**S01-3 [11:30]****Electric field dependent effects of transcranial direct current stimulation of the motor cortex**Ilkka Laakso<sup>1</sup>, Marko Mikkonen<sup>1</sup> & Satoshi Tanaka<sup>2</sup><sup>1</sup>*Department of Electrical Engineering and Automation, Aalto University, Espoo, Finland, 00076*<sup>2</sup>*Laboratory of Psychology, Hamamatsu University School of Medicine, Hamamatsu, Japan, 431-3192***Keywords: Clinical (therapy), Static, Completed (unpublished)****Presented by: Ilkka Laakso**

Transcranial direct current stimulation (tDCS) generates weak electric fields that can modulate the excitability of the motor cortex. The changes in excitability are, however, highly variable between individuals. Recent findings suggest that anatomical differences give rise to large inter-individual variations in the electric fields, which could partly explain the variable excitability changes. Here, we used individualized MRI-based modelling to investigate the hypothesized effect of electric fields on response variability. The results in nine subjects suggested that the after-effects of 1 mA 10 min anodal tDCS were proportional to the electric fields in the motor cortex, higher fields producing larger increases in cortical excitability.

**S02-3 [11:30]****In vitro study with a multimethodological approach on human fibroblasts exposed to 2.45 GHz: Biological effects of continuous and pulsed wave signals**Elisa Regalbuto<sup>1, 2</sup>, Anna Anselmo<sup>1</sup>, Stefania De Sanctis<sup>1</sup>, Valeria Franchini<sup>1</sup>, Elisa Coluzzi<sup>2</sup>, Roberto Bei<sup>3</sup>, Monica Benvenuto<sup>3</sup>, Laura Masuelli<sup>4</sup>,Guglielmo d'Inzeo<sup>5</sup>, Alessandra Paffi<sup>5</sup>, Eugenio Trodella<sup>5</sup>, Florigio Lista<sup>1</sup> & Antonella Sgura<sup>2</sup><sup>1</sup>*Scientific Department, Army Medical Center of Rome, Rome, Italy, 00184*<sup>2</sup>*Department of Science, University of Rome "Roma Tre", Rome, Italy, 00146*<sup>3</sup>*Department of Clinical Sciences and Translational Medicine, University of Rome "Tor Vergata", Rome, Italy, 00133*<sup>4</sup>*Department of Experimental Medicine, University of Rome "La Sapienza", Rome, Italy, 00184*<sup>5</sup>*Department of Information Engineering, Electronics and Telecommunications, University of Rome "La Sapienza", Rome, Italy, 00184***Keywords: In vitro, RF/Microwaves, Work in Progress****Presented by: Alessandra Paffi**

In this study the potential genotoxic effects of 2.45 GHz, mainly used in Wi-Fi technologies, were evaluated on human fibroblasts with both continuous and pulsed signals. The aim of this research is to perform good quality investigation on the potential non-thermal biological effects induced by 2.45 GHz exposures by a well experimental design and a characterized exposure system.

**S01-4 [11:45]****STUDENT PAPER****A  $\mu$ TMS coil for ultra-focal noninvasive magnetic stimulation**Micol Colella<sup>1, 2</sup>, Rebecca M. Laher<sup>3</sup>, Daniel Z. Press<sup>3</sup>, Courtney E. McIlduff<sup>3</sup>, Seward B. Rutkove<sup>3</sup>, Alvaro Pascual-Leone<sup>3</sup>, Francesca Apollonio<sup>1</sup>, Micaela Liberti<sup>1</sup> & Giorgio Bonmassar<sup>2</sup><sup>1</sup>*Department of Information Engineering, Electronics and Telecommunications (DIET), University of Rome "La Sapienza", Rome, Italy, 00184*<sup>2</sup>*Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Charlestown, MA, USA, 02129*<sup>3</sup>*Berenson-Allen Center for Noninvasive Brain Stimulation, Department of Neurology, Beth Israel***S02-4 [11:45]****WITHDRAWN**

Deaconess Medical Center, Harvard Medical School, Boston, MA, USA, 02215

**Keywords: Clinical (therapy), Pulsed, Work in Progress**

**Presented by: Micol Colella**

A miniaturized figure-of-eight coil ( $\mu$ Coil) for TMS applications has been developed taking advantage of the Flex circuit technology. First experiments on volunteers demonstrated the ability of the  $\mu$ Coil to elicit sensorial action potentials of the peripheral nervous system. The necessity of reducing the size of standard TMS coils arises from the poor spatial resolution of the latter. The aim of this study is to present the first prototype of  $\mu$ Coil and its computational model. Numerical results confirmed that the  $\mu$ Coil is capable of inducing a focalized electric field inside the tissues with amplitudes up to 70V/m consistent with the observed peripheral nervous stimulation in healthy volunteers.

### **S01-5 [12:00]**

#### **Induced fields variation in deep brain regions due to head-specific H-coil design**

Mai Lu<sup>1</sup> & Shoogo Ueno<sup>2</sup>

<sup>1</sup>Key Lab. of Opt-Electronic Technology and Intelligent Control of Ministry of Education, Lanzhou Jiaotong University, Lanzhou, China, 730070

<sup>2</sup>Department of Applied Quantum Physics, Kyushu University, Fukuoka, Japan, 812-8581

**Keywords: Clinical (therapy), ELF/LF, Work in Progress**

**Presented by: Shoogo Ueno**

Stimulation of deeper brain structures by transcranial magnetic stimulation (TMS) plays a role in the study of reward and motivation mechanisms. H-coil was developed for deep transcranial magnetic stimulation (dTMS). This work presents the design of H-coil by employing different realistic head models. The induced magnetic and electric fields in head tissues were obtained by impedance method. It was found the head-specific H-coil will generate great variation of induced fields in brain tissues. For developing H-coil for child dTMS, the coil parameters, such as wire turns, magnitude of injected currents etc. should be carefully considered.

### **S02-5 [12:00]**

#### **STUDENT PAPER**

#### **Heat shock response of melanoma cells induced by continuous and pulsed millimeter-wave heating**

Rosa Orlacchio<sup>1</sup>, Yann Le Page<sup>2</sup>, Yves Le Dréan<sup>2</sup>, Rémy Le Guével<sup>3</sup>, Ronan Sauleau<sup>1</sup>, Stanislav Alekseev<sup>4</sup> & Maxim Zhadobov<sup>1</sup>

<sup>1</sup>Univ Rennes, CNRS, IETR – UMR 6164, F-35000, Rennes, France

<sup>2</sup>Univ Rennes, Inserm, EHESP, IRSET (Institut de recherche en santé, environnement et travail) – UMR\_S 1085, F-35000, Rennes, France

<sup>3</sup>ImPACcell, SFR Biosit, Univ Rennes, Rennes, France

<sup>4</sup>Institute of Cell Biophysics of Russian Academy of Sciences, Pushchino, Russian Federation

**Keywords: In vitro, RF/Microwaves, Completed (unpublished)**

**Presented by: Rosa Orlacchio**

This study aims to evaluate the heat shock response of in vitro melanoma cells exposed to continuous or pulsed-modulated millimeter wave (MMW)-induced heating with the same average temperature rise. The phosphorylation of a small heat shock protein (HSP27) was detected 6 h post exposure using an experimental approach based on microscopy image analysis to follow the spatial variation of the biological response. Results evidenced that thermal pulses with a duration of 1.5 s induced significantly higher heat shock response in the melanoma cell monolayer than the one induced by continuous heating with the same average temperature dynamics.

**S01-6 [12:15]  
STUDENT PAPER**

**Electrostimulation thresholds for transcranial magnetic stimulation**

Marko Mikkonen<sup>1</sup>, Marco Soldati<sup>1</sup>, Ilkka Laakso<sup>1</sup>, Takenobu Murakami<sup>2</sup>, Yoshikazu Ugawa<sup>2</sup>, Satoshi Tanaka<sup>3</sup> & Akimasa Hirata<sup>4</sup>

<sup>1</sup>*Department of Electrical Engineering and Automation, Aalto University, Espoo, Finland*

<sup>2</sup>*Department of Neurology, Fukushima Medical University, Fukushima, Japan*

<sup>3</sup>*Laboratory of Psychology, Hamamatsu University School of Medicine, Hamamatsu, Japan*

<sup>4</sup>*Department of Computer Science and Engineering, Nagoya Institute of Technology, Nagoya, Japan*

**Keywords: Dosimetry (computational), IF, Completed (unpublished)**

**Presented by: Marko Mikkonen**

We studied the electrostimulation thresholds using transcranial magnetic stimulation. This was done using resting motor threshold data from two different muscles on opposing sides of the body and employing subjects' individual MRI in modeling of the cortical electric fields. We found that the stimulation threshold at the target is approximately 100 V/m and that the threshold for stimulating a muscle at rest does not differ for two different muscles on opposing sides of the body.

**S02-6 [12:15]  
WITHDRAWN**

**Lunch  
Monday June 24, 2019 • 12:30 - 14:00  
Joffre 1**

**Session: FA  
Student Flash Poster Session A  
Monday June 24, 2019 • 14:00 - 15:00  
Einstein  
Chairs: Niels Kuster & Christopher Portier**

**Session: PA  
Poster Session A  
Monday June 24, 2019 • 15:00 - 16:30  
Joffre 2-3**

**Coffee Break  
Monday June 24, 2019 • 16:30 - 17:00  
Joffre 2-3**

**Session: S03**  
**Numerical dosimetry of RF fields**  
**Monday June 24, 2019 • 17:00 - 18:30**  
**Einstein**  
**Chairs: Guangdi Chen & Wout Joseph**

**S03-1 [17:00]**

**The effect of vasculature detailedness on thermal estimations in next generation anatomical human models**

Manuel Murbach<sup>1</sup>, Bryn Lloyd<sup>1</sup>, Silvia Farcito<sup>1</sup>, Esra Neufeld<sup>1</sup> & Niels Kuster<sup>1, 2</sup>

<sup>1</sup>IT'IS Foundation, Zurich, Switzerland, 8004

<sup>2</sup>ETH Zurich, Zurich, Switzerland, 8092

**Keywords: Dosimetry (computational),**

**RF/Microwaves, Work in Progress**

**Presented by: Manuel Murbach**

The numerical assessment of the radiofrequency (RF)-induced local temperature increase inside a patient undergoing magnetic resonance imaging (MRI) diagnostics is state-of-the-art in MRI safety studies. In light of the continuous improvement in the resolution of anatomical models, we investigated the impact of the level of detail in the vasculature models on estimates of temperature increase. Results show that the difference of the peak temperature increase for the investigated high-exposure scenario is in the order of 20%. Future investigations should broaden the studied exposure scenarios and consider vascular convection.

**S03-2 [17:15] - YOUNG SCIENTIST PAPER**

**THz absorption pattern in modelled human skin with its appendages**

Alireza Lajevardipour<sup>1</sup>, Zoltan Vilagosh<sup>1</sup> & Andrew Wood<sup>1</sup>

<sup>1</sup>Health and Medical Sciences, Swinburne University of Technology, Melbourne, Australia, 3122

**Keywords: Dosimetry (computational), THz, Work in Progress**

**Presented by: Alireza Lajevardipour**

**Session: S04**  
**Effects of electromagnetic fields (in-vivo)**  
**Monday June 24, 2019 • 17:00 - 18:30**  
**Barthez**  
**Chairs: Florence Poulletier De Gannes & Richard Nuccitelli**

**S04-1 [17:00]**

**Gene responses to GSM-1800 MHz electromagnetic field in brain cells affected by a neuroinflammatory reaction**

Julie Lameth<sup>1</sup>, Severine Boillée<sup>1</sup>, Delia Arnaud-Cormos<sup>2</sup>, Philippe Leveque<sup>2</sup>, Jean-Marc Edeline<sup>3</sup> & Michel Mallat<sup>1</sup>

<sup>1</sup>INSERM U.1127, Institut du cerveau et de la moelle (ICM), Paris, France, 75013

<sup>2</sup>CNRS, XLIM, UMR 7252, Université de Limoges, Limoges, France, 87000

<sup>3</sup>UMR 9197 CNRS, université Paris-Sud, Paris Saclay Institute of Neuroscience, Neuro-PSI, Paris, France, 91405

**Keywords: In vivo, RF/Microwaves, Completed (unpublished)**

**Presented by: Michel Mallat**

We have investigated gene responses to a 2 h head exposure to GSM-1800 MHz in rats undergoing neuroinflammation. mRNA profiling (RNA seq) was performed in a area of the cerebral cortex where the mean SAR value was 3.22 W/Kg. GSM exposure induced significant modulations in the transcript level of 321 genes, including genes involved in protein dephosphorylation or ubiquitination. Quantitative RT-PCR analyses of a set of GSM-responsive genes confirmed RNA seq data and showed that significant gene responses also occurred in the entorhinal cerebral cortex where the SAR was reduced to 1.21 W/Kg. In contrast, none of these genes were affected in GSM-exposed healthy rats, indicating that neuroinflammation promoted gene responses to GSM signals.

**S04-2 [17:15]**

**Superficial damage to skin from 5.8, 8.2, and 95 GHz microwave exposures in swine**

William Voorhees<sup>1</sup>, James E Parker<sup>3</sup>, Christine Kowalczewski<sup>2</sup>, Jason Payne<sup>1</sup>, Andrew Kowalczewski<sup>2</sup>, Robert Christy<sup>2</sup> & Jeffrey Whitmore<sup>1</sup>

<sup>1</sup>Radio Frequency Bioeffects Branch, Air Force Research Laboratory, JBSA Fort Sam Houston, San Antonio, Texas, USA, 78234

<sup>2</sup>US Army Institute of Surgical Research, JBSA Fort

A model human skin with hair and associated bacterial spores is exposed to 1 THz radiation and SAR values computed, using dielectric values for each layer extrapolated from literature values. SAR was computed purely to measure energy absorption rather than temperature rise. The FDTD simulations indicate strong fields induced in lipid part of spore, in cortex layer of hair and within sweat duct. For an excitation with a plane wave of 1 V/m, the averaged SAR values reduces by increasing radius of cylindrical skin model. The max SAR value (0.0625 W/kg) happens in inner membrane of spores. In the case of sweat duct, max SAR values are vastly dependent on how to choose conductivity values.

### **S03-3 [17:30]**

#### **STUDENT PAPER**

##### **Hybrid Ray-Tracing/Finite-Difference Time-Domain method for user EMF-exposure assessment of a massive MIMO technology**

Sergei Shikhantsov<sup>1</sup>, Arno Thielens<sup>1, 2</sup>, Gunter Vermeeren<sup>1</sup>, Emmeric Tanghe<sup>1</sup>, Piet Demeester<sup>1</sup>, Guy Torfs<sup>1</sup>, Luc Martens<sup>1</sup> & Wout Joseph<sup>1</sup>

<sup>1</sup>Department of Information Technology, Ghent University/IMEC, Ghent, Belgium, 9000

<sup>2</sup>Department of Electrical Engineering and Computer Sciences, University of California Berkeley, Berkeley, CA, USA, 94704

**Keywords: Dosimetry (computational), RF/Microwaves, Completed (unpublished)**  
**Presented by: Sergei Shikhantsov**

The paper presents a novel method for numerical assessment of the massive MIMO exposure. Ray-tracing is used for a site-specific propagation modeling and the Finite-Difference Time-Domain method is applied to evaluate exposure of a realistic human phantom in terms of the Specific Absorption Rate. We discuss in detail the impact of the coupling between the user equipment and the phantom on the massive MIMO channel and propose a technique to incorporate it into the ray-tracing results for a more accurate exposure estimate. We show that the coupling with the head results in up to 19 dB variation of the incident electric field.

Sam Houston, San Antonio, Texas, USA, 78234

<sup>3</sup>General Dynamics Information Technology, JBSA Fort Sam Houston, San Antonio, Texas, USA, 78234

**Keywords: In vivo, RF/Microwaves, Work in Progress**

**Presented by: William Voorhees**

The 711th Human Performance Wing, Radio Frequency Bioeffects Branch (711 HPW/RHDR) is undertaking a multi-disciplinary, research effort to improve estimates of damage thresholds across the RF spectrum. This effort, referred to as Probability of Injury from RF Exposure (PIRE), will require significant collaboration between physiology and dosimetry to assess the impact of RF energy at the low end of the spectrum since the energy is deposited throughout the body. This presentation is on the first set of experiments, which investigates skin burn thresholds for 5.6 GHz, 8.2 GHz, and 95 GHz exposures in the Yorkshire pig.

### **S04-3 [17:30]**

##### **Commentary on the recent findings of the NTP cell phone bioassay: Has thermal stress been underestimated?**

Jens Kuhne<sup>1</sup>, Janine-Alison Schmidt<sup>1</sup>, Dirk Geschwentner<sup>1</sup>, Blanka Pophof<sup>1</sup> & Gunde Ziegelberger<sup>1</sup>

<sup>1</sup>Radiation and Health, German Federal Office for Radiation Protection, Oberschleißheim/Neuherberg, Germany, 85764

**Keywords: In vivo, RF/Microwaves, Review, Commentary, Recommendation, Evaluation**  
**Presented by: Jens Kuhne**

Recently, the final reports of a large two year study on mice and rats exposed to chronic cell phone radiofrequency radiation (RFR) were published by the National Toxicology Program (NTP). The most prominent effects were observed in male rats. Assuming that the observed effects are indeed related to exposure, we discuss the results of the NTP-study in the context of thermal stress. Taking into account the results of the temperature measurements in the pilot studies performed in order to set appropriate SAR for the two year study, we argue that significant body heating in adult male rats is likely the cause for some of the findings. Suggestions how to improve future study designs are made.

### S03-4 [17:45] - YOUNG SCIENTIST PAPER

#### Exposure assessment of body-implanted capsules in the 100-MHz–5-GHz range

Denys Nikolayev<sup>1, 2</sup>, Wout Joseph<sup>2</sup>, Maxim Zhadobov<sup>3</sup>, Ronan Sauleau<sup>3</sup>, Luc Martens<sup>2</sup> & Anja Skrivervik<sup>1</sup>

<sup>1</sup>*Microwaves and Antennas Group (MAG), École polytechnique fédérale de Lausanne, Lausanne, Switzerland, CH-1015*

<sup>2</sup>*INTEC – WAVES, imec / Ghent University, Ghent, Belgium, BE-9052*

<sup>3</sup>*Univ Rennes, CNRS, IETR (Institut d'Électronique et de Télécommunications de Rennes) UMR–6164, Rennes, France, FR-35000*

**Keywords: Dosimetry (computational), RF/Microwaves, Completed (unpublished)**

**Presented by: Denys Nikolayev**

Body-implanted bioelectronics rely on antennas to interface with external on- or off-body equipment. For a given input power, the antenna type and operating frequency significantly affect the power dissipation in tissues. This study addresses the exposure by realistic magnetic and electric equivalent sources using full-wave modeling techniques. The effect of equivalent source configuration on the power dissipation, exposure, and radiation performance is here quantified for the first time. The results demonstrate the existence of mode-dependent optimal operating frequency that maximizes the achievable radiation efficiency and minimizes Specific Absorption Rate (SAR) for a given input power.

### S03-5 [18:00]

#### Design and dosimetric characterization of an exposure facility for a human provocation study concerning possible effects of 2.45GHz WLAN radiation on sleep

Gernot Schmid<sup>1</sup>, Rene Hirtl<sup>1</sup>, Hans Dorn<sup>2</sup>, Torsten Eggert<sup>2</sup>, Ana Bueno-Lopez<sup>2</sup> & Heidi Danker-Hopfe<sup>2</sup>

<sup>1</sup>*EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, A-2444*

<sup>2</sup>*Charité - University Medicine Berlin, Berlin, Germany, D-12200*

**Keywords: Dosimetry (computational), RF/Microwaves, Completed (unpublished)**

**Presented by: Gernot Schmid**

The developed exposure facility deploys six simultaneously radiating patch antennas, arranged every 60° along a virtual circle of 120 cm diameter. This antenna arrangement is positioned upright (i.e. virtual circle in vertical plane) at the head end of the bed, such that the test subject's head is located in

### S04-4 [17:45]

#### Bioelectrical signaling regulates eye regeneration

Taylor Birkholz<sup>2</sup>, Cindy Kha<sup>1</sup>, Wendy Beane<sup>2</sup> & Kelly Ai-Sun Tseng<sup>1</sup>

<sup>1</sup>*School of Life Sciences, University of Nevada, Las Vegas, Las Vegas, NV, USA, 89154*

<sup>2</sup>*Biological Sciences, Western Michigan University, Kalamazoo, MI, USA, 49008*

**Keywords: In vivo, Static, Work in Progress**  
**Presented by: Kelly Ai-Sun Tseng**

Understanding how some animals can regenerate entire organs is critical for developing improved strategies for repair. We have identified a novel role for membrane potential, mediated by the V-ATPase proton pump, in regulating eye regrowth in both *Xenopus* tadpoles and planarian flatworms. Our data show that both eye fields are normally hyperpolarized. In both species, we found that ectopic hyperpolarization (by genetic ion transporter manipulation) resulted in the growth of extra eyes, while ectopic depolarization (by pharmacological ion transport modulation) inhibited eye regeneration. Together, these results suggest an ancestrally conserved regenerative bioelectrical pathway that regulates successful eye regeneration in diverse species.

### S04-5 [18:00]

WITHDRAWN

the center of the virtual circle. The computer controlled exposure facility allows double-blind and randomized application of realistic worst case WLAN exposure levels and sham exposure to the head of test subjects during sleep and continuous monitoring and recording of all relevant exposure metrics. The applied exposure signal represents different transmission conditions of real WLAN data traffic.

**S03-6 [18:15]  
STUDENT PAPER**

**Near-field relationship between maximum local SAR and maximum field intensity in FM frequencies**

Bader Fetouri<sup>1</sup>, Allal Ouberehil<sup>2</sup>, Philippe De Doncker<sup>3</sup> & Joe Wiart<sup>1</sup>

<sup>1</sup>C2M - LTCl, Telecom ParisTech, Paris, France, 75013

<sup>2</sup>TDF, Rennes, France

<sup>3</sup>ULB, Brussels, Belgium

**Keywords: Dosimetry (computational), RF/Microwaves, Completed (published)**  
**Presented by: Bader Fetouri**

This abstract dedicated to the near-field assessment of the specific absorption rate in FM frequencies. In this case the study focuses on linking maximum local specific absorption rate and maximum field intensity. We provide a new method to generalize electromagnetic field exposure.

**S04-6 [18:15]  
STUDENT PAPER**

**Effect of radiofrequency exposure on body temperature in mice**

Thi-Cuc Mai<sup>1, 2</sup>, Amandine Pelletier<sup>1, 2</sup> & Rene De Seze<sup>1, 2</sup>

<sup>1</sup>Experimental Toxicology , INERIS-National Institute of Industrial Environment and Risks, Verneuil-en-Halatte, France, 60550

<sup>2</sup>PériTox Laboratory UMR-I 01, Jules Verne University of Picardy, Amiens, France, 80025

**Keywords: In vivo, RF/Microwaves, Work in Progress**  
**Presented by: Thi Cuc Mai**

The evolution of communication technology brings great benefits to our daily life. Besides, this rapid expansion has raised concerns about their possible impact on public health. In this study, we found that repeated exposure to a low intensity 900 MHz radiofrequency induced changes in body temperature of mice. However, TRPM8 receptors don't seem to be involved in mediating the effect of radiofrequency.

**Student Ice Breaker**  
**Monday June 24, 2019 • 19:30 - 22:00**  
**Le Clandestin piano-bar**

**Tuesday June 25, 2019**

**Session: P2**  
**Plenary 2 - Has evidence for carcinogenicity of RF-EMF changed since IARC's assessment?**

**Tuesday June 25, 2019 • 08:30 - 09:30**

**Einstein**

**Chairs: Martin Rööfli & Elisabeth Cardis**

**P2-1 [08:30]**

**Update on epidemiological research**

Maria Feychting<sup>1</sup>

<sup>1</sup>*Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden, 17177*



**Biographical sketch**

Maria Feychting is Professor of Epidemiology at Karolinska Institutet, Institute of Environmental Medicine, and Head of the Unit of Epidemiology. Her research is focused on risk factors for chronic diseases, primarily cancer but also other chronic diseases. She has a specific interest in childhood cancer and adult brain tumors, both in terms of risk factors such as environmental and genetic factors, and factors affecting survival, as well as long-term socioeconomic consequences of childhood cancer. She has conducted research on potential health effects of non-ionizing radiation since the late 1980s, and she is the PI for the Swedish parts of the Interphone study, the Cefalo study, the Sotan study and the COSMOS study. She has extensive experience from register based research utilizing nationwide health data registers and combining data from the Nordic countries. She has published around 300 original scientific articles, brief communications, review articles, editorials, letters, and book chapters,

including 208 articles listed in PubMed (WoS h-index 51). She is currently the PI of several registry based studies on brain tumors, childhood cancers, and genetic syndromes, funded by the main Swedish national research councils, the Swedish Cancer Society, and Nordforsk. She has been invited expert in several health risk assessment expert groups, e.g. for the WHO, and other international and national scientific committees. Since May 2012, she is the vice Chairman of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), an independent body suggesting science based guidelines for non-ionizing radiation protection. She teaches advanced epidemiology courses at the Karolinska Institutet PhD program in epidemiology, and the Master of Public Health Program "Public Health Epidemiology".

**Abstract**

In 2011 the International Agency for Research on Cancer (IARC) reviewed the scientific literature on the potential carcinogenic effect of exposure to radiofrequency electromagnetic fields. Based on epidemiologic data from some case-control studies on mobile phone use and brain tumor risk (the Interphone study and a set of case-control studies from the Hardell group in Sweden), the IARC working group concluded that there was limited evidence from studies in humans for an effect of radiofrequency field exposure on the risk of glioma and acoustic neuroma. Evidence from a prospective cohort study which reported no associations was considered affected by non-differential exposure misclassification and available incidence time trend studies, which saw no increase in the occurrence of these tumors, were assessed as covering a too short time period to be informative. Within the working group a minority opinion assessed the evidence as inadequate, and judged the case-control studies as inconsistent and pointed to the lack of increased rates of glioma and acoustic neuroma since the introduction of mobile phones. Since the IARC evaluation, a number of additional case-control studies and prospective cohort studies have been published, including also the first study on brain tumors in children, as well as a considerable number of incidence time trend studies from different countries, covering an additional 10-15 years of observation, in total almost 30 years since handheld mobile phones were introduced. Furthermore, incidence trend simulation studies have been conducted where the expected incidence trends have been modelled under different assumptions of risk, as a consistency check of results from the case-control studies. Additional data are also available that shed light on the observed reduced risk estimates in some case-control studies, such as the Interphone study. This presentation will summarize the evidence from epidemiological studies published since the IARC evaluation.

**P2-2 [09:00]**

**Update on animal research**

Florence Poullétier De Gannes<sup>1</sup>

<sup>1</sup>*Laboratoire de l'Intégration du Matériau au Système, CNRS UMR 5218, Talence, France, 33400*



**Biographical sketch**

Florence Poullétier de Gannes got her PhD in Biological and Health Sciences from the University of Bordeaux, France. She joined the Bioelectromagnetics group of the IMS laboratory as postdoc in 2001 and she is still involved with the team as a CNRS research engineer. Her research deals mainly with the adverse and beneficial biological effects of non-invasive electromagnetic fields (RF and ELF) and is mostly oriented towards the CNS and neurological diseases. She has been involved in several programmes, both national (Ministry of research, French research foundation, ANR) and foreign (German BfS, Swiss research foundation Swiss research foundation and European Geronimo project). She has also worked on EMF health risk assessment in vitro and in vivo (animals) studies, within the European EFHRAN project.

She is a reviewer for major journals in the field of bioelectromagnetics (Bioelectromagnetics and Radiation Research). Florence Poullétier de

Gannes is an elected member of EBEA committee. She is author of twenty-four peer-reviewed papers and more than hundred meeting publications in the field of Bioelectromagnetics.

**Abstract**

In 2011, IARC classified RF-EMF as possibly carcinogenic for humans, mainly based on the Interphone study and Hardell results on mobile phone use and glioma as well as acoustic neuroma. However, animal studies were considered giving “limited evidence” for RF-EMF carcinogenicity. Since then various epidemiological and animal studies have been published, and in particular the so-called “NTP study” performed in the USA. This raises the question about whether these new data have changed the evidence for carcinogenicity? An overview of the state of knowledge in animal researches will be given. Scientific arguments for and against a link between RF-EMF and carcinogenicity based on in vivo studies will be presented transparently.

**Coffee Break**  
**Tuesday June 25, 2019 • 09:30 - 10:00**  
**Joffre 2-3**

**Session: CA**  
**Chiabrera Award**  
**Tuesday June 25, 2019 • 10:00 - 11:00**  
**Einstein**  
**Chair: Anke Huss**

**CA-1 [10:00]**

**Personal RF exposure assessment in current and future telecommunication networks**

Arno Thielens<sup>1</sup>

<sup>1</sup>*Department of Information Technology (INTEC), Ghent University/imec, Ghent, Belgium*



**Biographical sketch**

Arno Thielens is a postdoctoral researcher at UC Berkeley and Ghent University. He received a M.S. degree and a Ph. D. degree in applied physics at Ghent University in 2010 and 2015, respectively. He is affiliated to Ghent University's Waves group as a postdoctoral researcher, where his research focuses on personal exposure assessment to radio-frequency electromagnetic fields and numerical dosimetry. Since 2017, he is also a member of the Berkeley Wireless Research Center at the University of California, Berkeley, where he is working on: antenna design, body area networks, and the development of the human intranet.

Dr. Thielens is the recipient of the Joseph James Morrissey Memorial Award issued by the Bioelectromagnetics Society (BEMS) and the European Bio Electromagnetics Association (EBEA) in June 2013. He also received the 2015 URSI young scientist award. He obtained an FWO [PEGASUS]<sup>2</sup> Marie Skłodowska-Curie Fellowship in 2017 funded by the European Union's

Horizon 2020 research and innovation programme. He also received an Honorary Fellowship by the Belgian American Education Foundation (BAEF) in the same year.

**Abstract**

Radio-Frequency (RF) electromagnetic fields (EMFs) enable wireless communication between billions of users worldwide. Humans are exposed to these fields, but quantifying this exposure has proven to be challenging. There exist methods for measuring personal exposure to RF-EMFs emitted by far-field sources, but these are faced with uncertainties. This talk will present some techniques to reduce these measurement uncertainties and further improvements that could be made in the future, alongside measurements of exposure to near-field RF-EMF sources. These research efforts should improve our understanding of personal exposure to RF EMFs in the current telecommunication networks. However, future networks will use new technologies. Three of those are studied in terms of RF-EMF exposure: distributed small-cell networks, (massive) MiMo antennas, and higher carrier frequencies.

**Session: S05**  
**Epidemiological Studies**  
**Tuesday June 25, 2019 • 11:00 - 12:30**  
**Barthez**  
**Chairs: Maria Feychting & Anke Huss**

**S05-1 [11:00]**

**Long-term effect of mobile phone use on sleep quality: results from the Cohort Study of Mobile Phone Use and Health (COSMOS)**

Giorgio Tettamanti<sup>1</sup>, Anssi Auvinen<sup>2</sup>, Torbjörn Åkerstedt<sup>3</sup>, Katja Kojo<sup>4</sup>, Anders Ahlbom<sup>1</sup>, Sirpa Heinavaara<sup>5</sup>, Paul Elliott<sup>6</sup>, Mireille Toledano<sup>6</sup>,

**Session: S06**  
**Human Studies**  
**Tuesday June 25, 2019 • 11:00 - 12:30**  
**Einstein**  
**Chairs: Gunnhild Oftedal & Sarah Loughran**

**S06-1 [11:00]**

**STUDENT PAPER**

**RF-EMF exposure, sleep EEG, and memory consolidation**

Sheridan Findlay<sup>1, 2</sup>, Rodney Croft<sup>1, 2, 3</sup> & Sarah Loughran<sup>1, 2, 3</sup>

<sup>1</sup>*Australian Centre for Electromagnetic Bioeffects*

Joachim Schüz<sup>7</sup>, Isabelle Deltour<sup>7</sup>, Hans Kromhout<sup>8</sup>, Roel Vermeulen<sup>8</sup>, Christoffer Johansen<sup>9</sup>, Aslak Harbo Poulsen<sup>9</sup>, Maria Feychting<sup>1</sup> & Lena Hillert<sup>1</sup>

<sup>1</sup>*Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden, 17177*

<sup>2</sup>*Faculty of Social Sciences, Health Sciences, University of Tampere, Tampere, Finland, 33520*

<sup>3</sup>*Stress Research Institute, Stockholm University, Stockholm, Sweden, 10691*

<sup>4</sup>*STUK – Radiation and Nuclear Safety Authority, Environmental Radiation Surveillance and Emergency Preparedness, Helsinki, Finland*

<sup>5</sup>*Finnish Cancer Registry, Helsinki, Finland*

<sup>6</sup>*MRC-PHE Centre for Environment and Health, Department of Epidemiology and Biostatistics, School of Public Health, Imperial College London, London, United Kingdom*

<sup>7</sup>*Section of Environment and Radiation, International Agency for Research on Cancer, Lyon, France, 69372*

<sup>8</sup>*University of Utrecht, Institute for Risk Assessment Sciences, Utrecht, the Netherlands, 3508 TD*

<sup>9</sup>*Danish Cancer Society Research Center, Copenhagen, Denmark, DK 2100*

**Keywords: Epidemiology, RF/Microwaves, Completed (unpublished)**

**Presented by: Maria Feychting**

The majority of studies on the effect of radiofrequency fields from mobile phone use on sleep are cross-sectional; only a few prospective studies are available. In this study based on the Swedish and Finnish COSMOS participants, we evaluated whether operator recorded mobile phone calling time at baseline was associated with different sleep outcomes at the 4-year follow-up. The highest category of mobile phone call time was associated with a somewhat higher prevalence of insomnia. The effect estimate was slightly higher for calling time on the UMTS than on the GSM network, despite considerably higher RF exposure from GSM, suggesting that other aspects associated with extensive call time are more plausible explanations than RF field exposure.

## **S05-2 [11:15]**

***In-utero* Exposure to high magnetic field non-ionizing radiation and the risk of headaches and migraines in offspring: A prospective cohort study with up to 21 years of follow-up**

De-Kun Li<sup>1</sup>, Hong Chen<sup>1</sup>, Andrew Hirst<sup>1</sup>, Jeannette Ferber<sup>1</sup> & Roxana Odouli<sup>1</sup>

*Research, University of Wollongong, Wollongong, Australia, 2522*

<sup>2</sup>*School of Psychology, Illawarra Health & Medical Research Institute, University of Wollongong, Wollongong, Australia, 2522*

<sup>3</sup>*Population Health Research on Electromagnetic Energy, Monash University, Melbourne, Australia, 3800*

**Keywords: Human, RF/Microwaves, Completed (unpublished)**

**Presented by: Sheridan Findlay**

The purpose of the present study was to determine whether RF-EMF exposure immediately prior to sleep, improves memory consolidation, while also improving on previous methods by the use of repeated testing within the individual. The findings from the pilot data of this study showed no differences in sleep spindle frequency or memory consolidation between the sham and the active RF-EMF exposure conditions, however there is insufficient statistical power to draw strong conclusions. Data collection is now complete and the results of the full data set will be presented at the BioEM2019 conference.

## **S06-2 [11:15]**

### **STUDENT PAPER**

**Orientation and disorientation effects of a 50 mT extremely low frequency magnetic fields on human postural control**

Nicolas Bouisset<sup>1, 2</sup>, Sebastien Villard<sup>1, 2</sup>, Daniel Goulet<sup>7</sup>, Michel Plante<sup>7</sup>, Martine Souques<sup>6</sup>,

<sup>1</sup>*Division of Research, Kaiser Permanente, Oakland, CA, USA, 94611*

**Keywords: Epidemiology, Static, Completed (published)**

**Presented by: De-Kun Li**

In this prospective cohort study of 734 mother-child pairs, pregnant women were asked to carry an EMDEX meter to measure their level of exposure to magnetic field non-ionizing radiation (MF) during pregnancy. Their offspring were followed throughout childhood for any physician diagnosed headaches and/or migraines. Maternal exposure to high MF levels during pregnancy is associated with an increased risk of headaches and/or migraines in offspring. The association appears to be stronger for children with both headaches and migraines. Whites and male offspring also appeared to have a higher risk than non-Whites and female offspring, respectively.

François Deschamps<sup>5</sup>, Genevieve Ostiguy<sup>7</sup>, Jacques Lambrozo<sup>6</sup> & Alexandre Legros<sup>1, 2, 3, 4, 8</sup>

<sup>1</sup>*Human Threshold Research Group, Lawson Health Research Institute, London, ON, Canada*

<sup>2</sup>*Department of Kinesiology, Western University, London, ON, Canada*

<sup>3</sup>*Department of Medical Imaging, Western University, London, ON, Canada*

<sup>4</sup>*Department of Medical Biophysics, Western University, London, ON, Canada*

<sup>5</sup>*RTE, Département Concertation et Environnement, Cœur Défense, Paris-La Défense, France*

<sup>6</sup>*Service des Études médicales, EDF, Levallois-Perret Cedex, France*

<sup>7</sup>*Hydro-Québec, Montréal, Québec, Canada*

<sup>8</sup>*EuroMov, Université de Montpellier, Montpellier, France*

**Keywords: Human, ELF/LF, Work in Progress**  
**Presented by: Nicolas Bouisset**

Exposure to high levels of extremely low frequency magnetic fields (ELF-MF) modulates nervous system function, for example through magnetophosphenes perception. Electric and magnetic stimulation studies suggest that magnetophosphenes results from retinal cells activation. Given the close neurophysiological characteristics existing between the retina and the vestibular system, we chose to investigate the vestibular response to ELF-MF and electrical currents, and to analyze their impact on body sway. Here we find an orientation effect at 20 Hz and a disorientation effect at power line frequencies.

### **S05-3 [11:30]**

#### **Survival of glioma patients in relation to mobile phone use in Denmark, Finland and Sweden**

Ann Olsson<sup>1</sup>, Liacine Bouaoun<sup>1</sup>, Anssi Auvinen<sup>2</sup>, Maria Feychting<sup>3</sup>, Christoffer Johansen<sup>4</sup>, Tiit Mathiesen<sup>5</sup>, Beatrice Melin<sup>6</sup>, Anna Lahkola<sup>7</sup>, Suvi Larjavaara<sup>8</sup>, Anne-Sophie Villegier<sup>9</sup>, Graham Byrnes<sup>1</sup>, Isabelle Deltour<sup>1</sup> & Joachim Schüz<sup>1</sup>

<sup>1</sup>*Section of Environment and Radiation, International Agency for Research on Cancer, Lyon, France, 69372*

<sup>2</sup>*Faculty of Social Sciences, Health Sciences, University of Tampere, Tampere, Finland, 33520*

<sup>3</sup>*Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden, 171 77*

<sup>4</sup>*Oncology clinic, 5073 Rigshospitalet, University of Copenhagen, Copenhagen, Denmark, 2100*

### **S06-3 [11:30]**

#### **Magnetophosphenes perception and adaptation to the darkness: perception decreases as retinal sensitivity increases**

Sebastien Villard<sup>1, 2</sup>, Michael Corbacio<sup>1</sup>, Nicolas Bouisset<sup>2</sup>, Daniel Goulet<sup>3</sup>, Michel Plante<sup>3</sup>, Martine Souques<sup>4</sup>, François Deschamps<sup>5</sup>, Genevieve Ostiguy<sup>3</sup>, Jacques Lambrozo<sup>4</sup> & Alexandre Legros<sup>1, 2, 6, 7</sup>

<sup>1</sup>*Lawson Imaging, London, Ontario, Canada, N6A 4V2*

<sup>2</sup>*School of Kinesiology, University of Western Ontario, London, ON, Canada*

<sup>3</sup>*Hydro-Québec, Montréal, QC, Canada*

<sup>4</sup>*Service des Études Médicales, EDF, Paris, France*

<sup>5</sup>*Service Environnement Réseaux, RTE, Paris, France*

<sup>5</sup>Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden, 171 77

<sup>6</sup>Department of Radiation Sciences, Oncology, Umeå University Hospital, Umeå, Sweden, 901 87

<sup>7</sup>Radiation and Nuclear Safety Authority (STUK), Helsinki, Finland, 00880

<sup>8</sup>Helsinki University Hospital, Helsinki, Finland, 00290

<sup>9</sup>Toxicologie Expérimentale, INERIS, Verneuil-en-Halatte, France, 60550

**Keywords: Epidemiology, RF/Microwaves, Completed (published)**

**Presented by: Isabelle Deltour**

Gliomas are the most common cancer of the brain. We investigated whether pre-diagnostic mobile phone use was associated with survival. Glioma cases (n=806) in the INTERPHONE study in Denmark, Finland and Sweden were followed up for survival via registry linkages. Cox regression models were used to calculate hazard ratios and 95% confidence intervals. No reduced survival among glioblastoma patients was observed for various measures of mobile phone use relative to no or non-regular use. All significant associations suggested better survival for mobile phone users. Results were similar for high-grade and low-grade gliomas. In conclusion we found no evidence of reduced survival among glioma patients in relation to previous mobile phone use.

#### **S05-4 [11:45]**

##### **Radiofrequency electromagnetic fields, screen time, and cognitive function in children and adolescents at 9-18 years old**

Mònica Guxens<sup>1</sup>, Alba Cabré<sup>1</sup>, Luuk van Wel<sup>2</sup>, Ilaria Liorni<sup>3</sup>, Myles Capstick<sup>3</sup>, Roel Vermeulen<sup>2</sup>, Lúcia González<sup>4</sup>, Jesus Ibarluzea<sup>5</sup>, Maties Torrent<sup>6</sup> & Martine Vrijheid<sup>1</sup>

<sup>1</sup>ISGlobal, Barcelona, Spain

<sup>2</sup>IRAS, Utrecht University, Utrecht, the Netherlands

<sup>3</sup>IT'IS Foundation, Zurich, Switzerland

<sup>4</sup>FISABIO-UV-UJI, Valencia, Spain

<sup>5</sup>BIODONOSTIA, Donostia, Spain

<sup>6</sup>ib-Salut, Area de Salut de Menorca, Maó, Spain

**Keywords: Epidemiology, RF/Microwaves, Completed (unpublished)**

**Presented by: Monica Guxens**

We evaluated the association between radiofrequency electromagnetic fields (RF-EMF), screen time, and cognitive functions in children and adolescents aged 9-18 years. We found that RF-EMF dose to the brain was associated with poorer

<sup>6</sup>Medical Biophysics, University of Western Ontario, London, ON, Canada

<sup>7</sup>EuroMov, Université de Montpellier, Montpellier, France

**Keywords: Human, ELF/LF, Work in Progress Presented by: Sebastien Villard**

Magnetophosphene (MP) perception has been used as model of interaction between extremely low frequency magnetic fields (ELF-MF) and the central nervous system (CNS). The origin of this interaction is most likely retinal, but the underlying mechanisms remains unclear. We proposed to re-explore the adaptation to the darkness paradigm (Lovsund, 1980) to better understand the perception of MP at the photoreceptors level. 3 groups of 20 healthy participants will be exposed to respectively 20, 50 and 60Hz ELF-MF up to 75mT. MP thresholds were taken over 45 minutes in the dark. Observations from 26 participants show an increase in MP thresholds but no effect of the frequency of stimulation. A thorough discussion will be presented at the conference

#### **S06-4 [11:45]**

##### **Are there sex differences in possible effects of RF-EMF exposure on the macro- and microstructure of sleep between healthy elderly (60-80 years) men and women?**

Heidi Danker-Hopfe<sup>1</sup>, Hans Dorn<sup>1</sup>, Gernot Schmid<sup>2</sup>, Cornelia Sauter<sup>1</sup>, Rene Hirt<sup>2</sup> & Torsten Eggert<sup>1</sup>

<sup>1</sup>Competence Center of Sleep Medicine, Charité - University Medicine Berlin, Berlin, Germany, D-12200

<sup>2</sup>EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, A-2444

**Keywords: Human, RF/Microwaves, Completed (unpublished)**

**Presented by: Heidi Danker-Hopfe**

The study aims to analyse possible differences in RF-EMF effects on the macrostructure and the microstructure of sleep between healthy elderly men and women. The results indicate differences in effects of GSM 900 and TETRA exposure in healthy elderly (60-80 years) men and women. The results observed so far are not indicative of a disturbed sleep under RF-EMF exposure.

cognitive function including non-verbal IQ, attentional function, visuomotor coordination, and working memory. However, screen time has different pattern of association depending on the cognitive function.

#### **S05-5 [12:00]**

##### **Parental occupational exposure to low-frequency magnetic fields and risk of leukaemia in the offspring: Findings from the Childhood Leukaemia International Consortium (CLIC)**

Madar Talibov<sup>1</sup>, Ann Olsson<sup>1</sup>, Helen D. Bailey<sup>2</sup>, Friederike Erdmann<sup>3</sup>, Catherine Metayer<sup>4</sup>, Corrado Magnani<sup>5</sup>, Eleni T. Petridou<sup>6</sup>, Anssi Auvinen<sup>7</sup>, Logan G. Spector<sup>8</sup>, Jacqueline Clavel<sup>9</sup>, Eve Roman<sup>10</sup>, John D. Dockerty<sup>11</sup>, Atte Nikkilä<sup>12</sup>, Olli Lohi<sup>13</sup>, Alice Kang<sup>14</sup>, Theodora Psaltopoulou<sup>15</sup>, Lucia Miligi<sup>16</sup>, Javier Vila<sup>17</sup>, Elisabeth Cardis<sup>17</sup>, Isabelle Deltour<sup>1</sup> & Joachim Schüz<sup>1</sup>

<sup>1</sup>*Section of Environment and Radiation, International Agency for Research on Cancer, Lyon, France, 69372*

<sup>2</sup>*Telethon Kids Institute, University of Western Australia, Nedlands, Australia*

<sup>3</sup>*Childhood Cancer Research Group, Danish Cancer Society Research Centre, Copenhagen, Denmark, 2100*

<sup>4</sup>*School of Public Health, University of California, Berkeley, CA, USA, 94720*

<sup>5</sup>*Dipartimento di Medicina Traslazionale, SCU Epidemiologia del Tumori, Università del Piemonte Orientale, Novara, Italy, 28100*

<sup>6</sup>*Department of Hygiene, Epidemiology and Medical Statistics, National and Kapodistrian University of Athens Medical School, Athens, Greece, 11527*

<sup>7</sup>*Faculty of Social Sciences, Health Sciences, University of Tampere, Tampere, Finland, 33520*

<sup>8</sup>*Division of Epidemiology and Clinical Research, Department of Pediatrics, University of Minnesota, Minneapolis, MN, USA, 55455*

<sup>9</sup>*CRESS, UMRS 1153, INSERM, Villejuif, France, 94807*

<sup>10</sup>*Epidemiology and Cancer Statistics Group, Department of Health Sciences, University of York, Heslington, United Kingdom, YO10 5DD*

<sup>11</sup>*Department of Preventive and Social Medicine, University of Otago, Dunedin, New Zealand, 9054*

<sup>12</sup>*Faculty of Medicine and Biosciences, University of Tampere, Tampere, Finland, 33520*

<sup>13</sup>*Tampere Center for Child Health Research, University of Tampere, Tampere, Finland, 33014*

#### **S06-5 [12:00]**

##### **STUDENT PAPER**

##### **Effect of exposure to 900 MHz radiofrequency on the MEG alpha band activity at rest**

Jasmina Wallace<sup>1, 2</sup>, Lydia Yahia-Cherif<sup>3, 4</sup>, Christophe Gitton<sup>3, 4</sup>, Laurent Hugueville<sup>3, 4</sup>, Jean-Didier Lemaréchal<sup>3, 4</sup> & Brahim Selmaoui<sup>1, 2</sup>

<sup>1</sup>*Department of Experimental Toxicology, Institut National de l'Environnement Industriel et des Risques (INERIS), Verneuil-en-Halatte, France*

<sup>2</sup>*Peritox Laboratoire de Périnatalité & Risques Toxiques, Unité mixte INERIS, Université de Picardie Jules Verne, CURS, Amiens, France*

<sup>3</sup>*Centre De NeuroImagerie De Recherche - CENIR, Institut Du Cerveau Et De La Moelle Épinière - ICM, Paris, France*

<sup>4</sup>*Inserm U1127, CNRS UMR 7225, Institut Du Cerveau Et De La Moelle Épinière - ICM, Paris, France*

**Keywords: Clinical (diagnostics), RF/Microwaves, Work in Progress**  
**Presented by: Jasmina Wallace**

With the extensive use of mobile phones several studies have been realized to understand the effects of radiofrequency exposure on brain activity. Results show changes in the alpha band spectral power. To better understand the cortical structures involved in these changes after exposure at 900 MHz, we carried out electroencephalography and magnetoencephalography recordings followed by the anatomical magnetic resonance imaging. Healthy volunteers were selected according to strict inclusion criteria. Preliminary results on MEG sensor space showed a modification of the alpha band right after exposure. Data analyses of MEG recordings on sensor space and source space are still under process and ready results will be presented at the conference.

<sup>14</sup>*School of Public Health, University of California, Berkeley, CA, USA, 94720*

<sup>15</sup>*Department of Hygiene, Epidemiology and Medical Statistics, National and Kapodistrian University of Athens Medical School, Athens, Greece, 11527*

<sup>16</sup>*Occupational and Environmental Epidemiology Unit, ISPO Cancer Prevention and Research Institute, Florence, Italy, 50139*

<sup>17</sup>*ISGlobal, Barcelona Institute for Global Health, Barcelona, Spain, 08036*

**Keywords: Epidemiology, ELF/LF, Completed (unpublished)**

**Presented by: Isabelle Deltour**

Evidence from previously published studies on parental occupational exposure to extremely low-frequency magnetic fields (ELF-MF) and risk of leukemia in their offspring is inconsistent. 11 case-control studies including 9,723 childhood leukemia cases and 17,099 controls were pooled. Parental occupational ELF-MF exposure was assigned by linking jobs to an ELF-MF job-exposure matrix (JEM). The current study did not find association between parental occupational ELF-MF exposure and childhood leukemia.

#### **S05-6 [12:15]**

##### **Exposure of adults to ELF magnetic field in France: statistical analysis of the data**

Isabelle Magne<sup>1</sup>, Martine Souques<sup>1</sup>, Laurène Courouve<sup>2</sup>, Anne Duburcq<sup>2</sup>, Emmanuel Remy<sup>3</sup> & Pierre-André Cabanes<sup>1</sup>

<sup>1</sup>*Service of Medical Studies, EDF, Levallois-Perret, France, 92300*

<sup>2</sup>*Cemka-Eval, Bourg-la-Reine, France, 92340*

<sup>3</sup>*Performance, Industrial Risk, Monitoring for Maintenance and Operations Department, EDF R&D, Chatou, France, 78401*

**Keywords: Epidemiology, ELF/LF, Completed (unpublished)**

**Presented by: Isabelle Magne**

The exposure assessment to ELF magnetic fields remains an important question in the context of epidemiological studies. We present here the final results of the first study characterizing personal exposure of adults at a national scale. Descriptive statistical analyses were performed for all the adults, and only for adults where no alarm clock was identified, as in some cases this requirement of the measurement protocol was not respected. We looked in particular to the most exposed class, as to the adults living close to high voltage power line.

#### **S06-6 [12:15]**

##### **Electromagnetic hypersensitivity: A critical review of explanatory hypotheses**

Maël Dieudonné<sup>1</sup>

<sup>1</sup>*Max Weber Center (CMW), Lyon, France, 69007*

**Keywords: Behavioural, All Frequencies, Review, Commentary, Recommendation, Evaluation**

**Presented by: Maël Dieudonné**

Electromagnetic hypersensitivity (EHS) is a condition defined by the attribution of symptoms to electromagnetic fields (EMF). Its nature remains disputed despite a growing scientific literature. This presentation reviews critically the main explanatory hypotheses that have been put forward: (1) the electromagnetic hypothesis, attributing EHS to EMF exposure; (2) the cognitive hypothesis, assuming that EHS results from false beliefs in EMF harmfulness, promoting nocebo responses to perceived exposure; (3) the attributive hypothesis, conceiving EHS as a coping strategy for pre-existing conditions. The implications for future research are discussed in conclusion.

**Lunch**  
**Tuesday June 25, 2019 • 12:30 - 14:00**  
**Joffre 1**

**Session: M3**  
**EBEA Assembly**  
**Tuesday June 25, 2019 • 13:00 - 14:00**  
**Barthez**

**Session: FB**  
**Student Flash Poster Session B**  
**Tuesday June 25, 2019 • 14:00 - 15:00**  
**Einstein**  
**Chairs: Christopher Portier & Niels Kuster**

**Session: PB**  
**Poster Session B**  
**Tuesday June 25, 2019 • 15:00 - 16:30**  
**Joffre 2-3**

**Coffee Break**  
**Tuesday June 25, 2019 • 16:30 - 17:00**  
**Joffre 2-3**

**Session: W1**  
**Workshop 1 - Atmospheric**  
**electromagnetic field bioeffects**  
**Tuesday June 25, 2019 • 17:00 - 18:30**  
**Barthez**  
**Chairs: Michal Cifra & Lluís M. Mir**

**Session: W2**  
**Workshop 2 - Differences of exposure**  
**limits between the new ICNIRP**  
**Guidelines and IEEE C95.1 Standard**  
**Tuesday June 25, 2019 • 17:00 - 18:30**  
**Einstein**  
**Chairs: C. K. Chou & Eric Van Rongen**

**W1-1 [17:00]**

**Introduction of the workshop and Electromagnetic field COST action**

Michal Cifra<sup>1</sup> & Lluís M. Mir<sup>2</sup>

<sup>1</sup>*Bioelectrodynamics research team, Institute of Photonics and Electronics of the Czech Academy of Sciences, Prague, Czech Republic, 18200*

<sup>2</sup>*Vectorology and Anticancer Therapies, UMR 8203 CNRS, Univ. Paris-Sud, Gustave Roussy, Université Paris-Saclay, Villejuif, France*

**W2-1 [17:00]**

**Differences of exposure limits between the new ICNIRP guidelines and IEEE C95.1 standard**

C. K. Chou<sup>1</sup> & Eric Van Rongen<sup>2</sup>

<sup>1</sup>*ICES TC95, IEEE, Piscataway, New Jersey, USA, 08854*

<sup>2</sup>*ICNIRP, Munich, Germany, 85764*

Two international organizations develop EMF exposure limits. IEEE's involvement with RF safety issues predates the first C95.1 EMF standard published in 1966 by the American Standards Institute. The latest version of the IEEE C95.1 standard published in March 2019 covers 0 to 300 GHz. The International Commission on Non-Ionizing Radiation and Protection (ICNIRP), a collaborating organization of the World Health Organization, published guidelines for up to 300 GHz in 1998 and below 100 kHz in 2010. Currently, ICNIRP is working on revised guidelines for radiofrequencies above 100 kHz. Differences of the limits between IEEE C95.1-2019 and ICNIRP newly

developed radiofrequency limits will be the main discussion of this workshop.

#### **W1-2 [17:10]**

##### **Spectral perspective on natural Earth electromagnetic phenomena**

Michal Cifra<sup>1</sup>

<sup>1</sup>*Bioelectrodynamics research team, Institute of Photonics and Electronics of the Czech Academy of Sciences, Prague, Czech Republic, 18200*

This presentation is a part of the ATMOSPHERIC ELECTROMAGNETIC FIELD BIOEFFECTS workshop. We present here a brief overview of electromagnetic phenomena naturally present in the biotope of Earth organisms. Spectrally, the main focus is from 0 Hz to 300 GHz.

#### **W1-3 [17:30]**

##### **Atmospheric electricity and other “natural” voltage gradient sources: the case of pyroelectricity**

Lluís M. Mir<sup>1</sup>, Adeline Muscat<sup>1</sup>, Isabelle Leray<sup>1</sup> & Tomás García-Sánchez<sup>1</sup>

<sup>1</sup>*Vectorology and Anticancer Therapies, UMR 8203 CNRS, Univ. Paris-Sud, Gustave Roussy, Université Paris-Saclay, Villejuif, France*

Pyroelectricity consists in the generation of an electric field (EF) at the surface of some materials when a change in temperature is produced. Here tourmaline microparticles, which are known to display pyroelectrical properties, were subjected to different changes in temperature prior their exposure to cells in order to induce an EF at the cell surface. Then, changes in the permeability of the cell membrane to a nonpermeant cytotoxic agent were assessed by a cloning efficacy test. An increase in cell membrane permeability was only detected when tourmaline was subjected to a change in temperature, suggesting that an induced pyroelectrical EF on the material could actually be involved in the observed enhancement of the membrane permeability.

#### **W1-4 [17:50]**

##### **New insights from a Bayesian analysis of melatonin levels and low-frequency magnetic fields**

Nicolas Bouche<sup>1</sup> & Kevin McConway<sup>2</sup>

<sup>1</sup>*CRAL, University of Lyon1, St Genis Laval, France, F-69230*

<sup>2</sup>*Mathematics And Statistics, The Open University,*

#### **W2-2 [17:15]**

##### **Overview of the Revised International Commission on Non-Ionizing Radiation Protection (ICNIRP) Radiofrequency Guidelines**

Rodney Croft<sup>1, 2</sup>

<sup>1</sup>*School of Psychology, Illawarra Health & Medical Research Institute, University of Wollongong, Wollongong, Australia, 2522*

<sup>2</sup>*Australian Centre for Electromagnetic Bioeffects Research, Wollongong, Australia, 2522*

This talk provides an overview of the upcoming International Commission on Non-Ionizing Radiation Protection (ICNIRP) radiofrequency guidelines.

#### **W2-3 [17:30]**

##### **Review of dosimetry studies for setting the ICNIRP Guidelines**

Akimasa Hirata<sup>1, 2</sup>

<sup>1</sup>*Department of Electrical and Mechanical Engineering, Nagoya Institute of Technology, Nagoya, Japan, 466-8555*

<sup>2</sup>*Center of Biomedical Physics and Information Technology, Nagoya Institute of Technology, Nagoya, Japan, 466-8555*

This talk reviews the rationale of the metrics, basic restrictions, and reference levels in the upcoming International Commission on Non-Ionizing Radiation Protection (ICNIRP) radiofrequency guidelines.

#### **W2-4 [17:45]**

##### **Thermal modeling and IEEE RF exposure limits above 6 GHz**

Kenneth Foster<sup>1</sup>, Marvin Ziskin<sup>2</sup> & Quirino Balzano<sup>3</sup>

<sup>1</sup>*Department of Bioengineering, University of Pennsylvania, Philadelphia, PA, USA, 19104*

<sup>2</sup>*Temple University Medical School, Philadelphia, PA, USA, 19104*

*Milton Keynes, United Kingdom, MK7 6AA*

The epidemiological study of Wertheimer<sup>1979</sup> raised concerns for adverse health effects due to Extremely Low Frequency magnetic fields (ELF MF) generated by power lines. Since, epidemiological studies and laboratory studies on rats have often been contradictory. Here, we revisit the possible connection between ELF MF and the biomarker Melatonin in humans and laboratory rats using two modern approaches: a Bayesian model and a non-parametric approach. Both methods reveal the same surprising well ordered pattern which reconciles past contradictory results.

**W1-5 [18:10]**

**Roundtable: Open contributions on the “atmospheric electricity and EMF” - facts, hypothesis and consequences on the biological objects and their evolution**

<sup>3</sup>*Department of Electrical and Computer Engineering, University of Maryland, College Park, MD, USA, 20742*

This talk reviews the rationale for revisions of IEEE C95.1 RF exposure limits above the “transition frequency” of 6 GHz, where the limits (the exposure reference level, ERL) are expressed in terms of power density incident on skin.

**W2-5 [18:00]**

**Differences of exposure limits between the new ICNIRP Guidelines and IEEE C95.1 Standard**

Richard Tell<sup>1</sup>

<sup>1</sup>*Richard Tell Associates, Inc, 10037 Long Meadow Road, Madison, AL, USA, 35756*

Two specific aspects of the new IEEE standard C95.1 and how it differs from the proposed revision of the ICNIRP Guidelines on RF exposure are discussed. These two issues are (a) the designation of who may be exposed to specific levels of RF energy and (b) limits on local exposure. Both the IEEE standard and ICNIRP guidelines incorporate upper and lower tiers of exposure limits.

**Conference Dinner  
Tuesday June 25, 2019 • 19:00 - 23:00  
Domaine des Mours**

**Wednesday June 26, 2019**

**Session: P3**  
**Plenary 3 - 5G real-life exposure: how to assess and optimize?**  
**Wednesday June 26, 2019 • 09:00 - 10:30**  
**Einstein**  
**Chairs: Luc Martens & Sami Gabriel**

**P3-1 [09:00]**

**Procedures for in-situ 5G-NR MaMIMO exposure evaluation and first trial results**

Wout Joseph<sup>1</sup>

<sup>1</sup>*Department of Information Technology (INTEC), Ghent University/imec, Ghent, Belgium*



**Biographical sketch**

Wout Joseph was born in Ostend, Belgium on October 21, 1977. He received the M. Sc. degree in electrical engineering from Ghent University (Belgium), in July 2000. From September 2000 to March 2005 he was a research assistant at the Department of Information Technology (INTEC) of the same university. During this period, his scientific work was focused on electromagnetic exposure assessment. His research work dealt with measuring and modelling of electromagnetic fields around base stations for mobile communications related to the health effects of the exposure to electromagnetic radiation. This work led to a Ph. D. degree in March 2005. He was postdoctoral researcher for iMinds-UGent/INTEC until 2009. From October 2007 to October 2013, he was a Post-Doctoral Fellow of the FWO-V (Research Foundation – Flanders). Since October 2009, he is professor in the domain of Experimental Characterization of wireless communication systems. He is IMEC PI since 2017. His professional

interests are electromagnetic field exposure assessment, in-body electromagnetic field modelling, electromagnetic medical applications, propagation for wireless communication systems, IoT, antennas and calibration.

**Abstract**

The first commercial 5G mobile networks are being deployed at the end of 2018 and people will be exposed to this new technology. Regulators urgently need in-situ evaluations and will need to have procedures and tools for the assessment of realistic human exposure. This leads to a need of on-site (in situ) measurements of the RF exposure from the 5G base station radios taken into operation.

The 5G mobile networks being rolled-out consist of 5G new radio (NR) technology, Massive MIMO (MaMIMO) where the base stations will in most cases use beamforming, small cells, and mm-wave technology. MaMIMO as 5G technology enables benefits such as excellent spectral efficiency and superior energy efficiency. The main concept is to use large base station antenna arrays to simultaneously serve multiple user equipment.

Up to now, there is no methodology available on how to conduct in-situ 5G exposure measurements, nor to perform 5G network planning with minimal exposure. An important challenge is to obtain correct realistic exposure and avoid unrealistic overestimations by assuming continuous beamforming.

The aim of this plenary is to propose in a general understandable way (i) new measurement methodologies to assess the instantaneous as well as (realistic) maximum 5G exposure, (ii) first in-situ 5G base station exposure assessments, (iii) insights into 5G-NR equipment, device usage and 5G field distributions, (iv) and concepts for 5G network planning with minimal exposure.

**P3-2 [09:10]**

**5G network planning with minimum exposure in real environments**

Margot Deruyck<sup>1</sup>

<sup>1</sup>*Department of Information Technology (INTEC), Ghent University/imec, Ghent, Belgium*

**Biographical sketch**

Margot Deruyck was born in Kortrijk, Belgium, on July 14, 1985. She received the M. Sc. degree in Computer Science Engineering and the Ph. D. degree from Ghent University, Ghent, Belgium, in 2009 and 2015, respectively. From September 2009 to January 2015, she was a Research Assistant with Ghent University - IMEC – WAVES (Wireless, Acoustics, Environment & Expert Systems – Department of Information Technology). Her scientific work is focused on green wireless access networks with minimal power consumption and minimal exposure from human beings. This work led to the Ph.D. degree. Since January 2015, she has been a Postdoctoral Researcher at the same institution where she continues her work in green wireless access network planning. Since October 2016, she is a Post-Doctoral Fellow of the FWO-V (Research Foundation - Flanders).

## Abstract



In the last decades, not only an increase in mobile devices has been noticed, but these devices are also becoming more powerful, allowing quite demanding services such as streaming music or video. Wireless access networks need to expand to cope with these extra demands to keep the user satisfied. Wireless network planning is a complex problem which targets the minimization of CAPEX by the network operator by jointly (i) selecting proper locations for the sites hosting the base stations; (ii) dimensioning the radio equipment installed at each BS, and (iii) fulfilling performance constraints on coverage, capacity, and quality of service perceived by end users.

Besides network expansion, new technologies are being developed such as 5G NR (New Radio) with features like massive MIMO, beamforming, small cells and the use of mm-wave frequencies. Similar as for the currently deployed 2 to 4G technologies, the new 5G deployments will have to satisfy applicable regulations on Electromagnetic Field exposure.

Factoring in both EMF exposure limits and the 5G specifications in terms of EMF emissions further complicates the network planning described above. This talk will discuss 5G network planning accounting for human exposure, as well as the minimization of the global network exposure.

## P3-3 [09:20]

### 5G small cells and MaMIMO exposure assessment in real environments

Joe Wiaart<sup>1</sup>

<sup>1</sup>Chaire C2M, Télécom ParisTech, Paris, France

## P3-4 [09:30]

### Determination of time-averaged power levels for assessment of actual RF-EMF exposure from massive MIMO antennas

Christer Tornevik<sup>1</sup>

<sup>1</sup>Ericsson Research, Ericsson AB, Stockholm, Sweden



## Biographical sketch

Christer Törnevik received the M.Sc. degree in applied physics from the Linköping University, Linköping, Sweden, in 1986, and the Licentiate degree in materials science from the Royal Institute of Technology, Stockholm, Sweden, in 1991. He joined Ericsson in 1991. Since 1993, he has been involved in research activities related to radio frequency exposure from wireless communication equipment. He is currently a Senior Expert with responsibility for electromagnetic fields and health within the Ericsson Group. From 2003 to 2005, he was the Chairman of the Mobile & Wireless Forum, where he is currently the Secretary of the Board. Since 2006, he has been leading the Technical Committee on electromagnetic fields of the Swedish Electrotechnical Standardization Organization, SEK, and he has as an expert contributed to the development of several CENELEC, IEC, ITU and IEEE standards on the assessment of RF exposure from wireless

equipment.

**P3-5 [09:40]**

**How to assess RF exposure compliance of base stations based on actual network service**

Christophe Grangeat<sup>1</sup>

<sup>1</sup>*Nokia Bell Labs, Stuttgart, Germany*



**Biographical sketch**

Christophe Grangeat has almost 30-year experience in managing innovation and technologies dealing with EMF exposure and sustainable telecom networks. He is currently RF exposure and energy efficiency Senior Specialist within the 5G & Small Cells Business Unit of Nokia Mobile Networks Business Group. He is coordinating activities involving products and features architecture design, portfolio management, R&D, compliance assessment and standardization. He contributed to multiple research projects such as Comobio, Adonis, OperaNet and SooGreen. He is actively developing and coordinating international standards within the IEC, CENELEC, ITU and ETSI. He is co-convenor of IEC TC106 MT3. He is promoting stakeholder's dialog through industry fora like the GSMA or the Small Cell Forum.

**P3-6 [09:50]**

**Assessment of maximally allowable power-density averaging area for conservative electromagnetic exposure assessment above 6 GHz**

Manuel Murbach<sup>1</sup>

<sup>1</sup>*IT'IS Foundation, Zurich, Switzerland, 8004*

**P3-7 [10:00]**

**Round table**

**Coffee Break**  
**Wednesday June 26, 2019 • 10:30 - 11:00**  
**Joffre 2-3**

**Session: T1**  
**Tutorial 1 - Body temperature regulation in Mammals**  
**Wednesday June 26, 2019 • 11:00 - 12:00**  
**Einstein**  
**Chairs: Rene De Seze & Carmela Marino**

**T1-1 [11:00]**

**Body temperature regulation in mammals**

Shaun Morrison<sup>1</sup>

<sup>1</sup>*Oregon Health & Science University, Portland, OR, USA*



**Biographical sketch**

Dr. Shaun Morrison received his Ph.D. in Physiology and Biophysics from the University of Vermont, defending a thesis on the central nervous system regulation of blood pressure in spontaneously hypertensive rats. At Cornell University, he continued to study the neural circuits in the brain that regulate the sympathetic nerve activity to blood vessels. As a Professor of Physiology at Northwestern University, he pioneered neurophysiological investigations into the neural basis for the differential brain regulation of the sympathetic outflows to different tissues, including the adrenal gland and the brown adipose tissue. These studies led to a focus on the brain regulation of body temperature, which Dr. Morrison has pursued at Oregon Health and Sciences University, where he is a Professor in the Department of Neurological Surgery. Of particular interest are the brain mechanisms controlling heat production in brown adipose tissue and through skeletal muscle shivering.

**Abstract**

Maintenance of a homeostatic body core temperature is a critical brain function accomplished by a central neural network which orchestrates a complex behavioral and autonomic repertoire in response to environmental temperature challenges or to declining energy homeostasis, and in support of immune responses and many behavioral states, including stress, sleep, and reproduction. This tutorial will present an overview of the anatomical, neurotransmitter, and functional relationships within the central neural network that controls the principal thermoeffectors: cutaneous vasoconstriction regulating heat loss, and shivering and brown adipose tissue for heat production. The core thermoregulatory network regulating these thermoeffectors consists of parallel but distinct central efferent pathways that share a common peripheral thermal sensory input. Hopefully this précis will provide a framework for understanding potential central neural mechanisms which may underlie the effects of exposure to radio frequency electromagnetic fields on body temperature. Supported by USPHS National Institutes of Health grant R01 NS091066.

**Session: S07**  
**Risk, Safety Standards & Policy**  
**Wednesday June 26, 2019 • 12:00 - 13:00**  
**Einstein**  
**Chairs: Andrew Wood & Rodney Croft**

**S07-1 [12:00]**

**Application of non-ionizing radiation on humans for non-medical purposes. New regulation in Germany**

Blanka Pophof<sup>1</sup>, Monika Asmuss<sup>1</sup>, Jens Kuhne<sup>1</sup>, Daniela Weiskopf<sup>1</sup> & Gunde Ziegelberger<sup>1</sup>

<sup>1</sup>*Radiation and Health, Federal Office for Radiation Protection, Oberschleißheim/Neuherberg, Germany, D-85764*

**Keywords: Public Health Policy, All Frequencies, Completed (published)**

**Presented by: Blanka Pophof**

In December 2018 Germany released a new ordinance to protect customers from adverse effects of non-ionizing radiation applied to humans for cosmetic and other non-medical purposes. It covers the commercial application of optical radiation, electric, magnetic and electromagnetic fields and ultrasound. The ordinance will enter into force on December 31st 2020.

**S07-2 [12:15]**

**Consistency of electromagnetic exposure safety frameworks for localized and pulsed exposure above 6 GHz**

Esra Neufeld<sup>1</sup>, Theodoros Samaras<sup>2</sup> & Niels Kuster<sup>1, 3</sup>

<sup>1</sup>*Foundation for Research on Information Technologies in Society (IT<sup>2</sup>IS Found, Zurich, Switzerland, 8004*

<sup>2</sup>*Department of Physics, Aristotle University of*

**Session: S08**  
**Effects of ELF magnetic fields (in-vitro)**  
**Wednesday June 26, 2019 • 12:00 - 13:00**  
**Barthez**  
**Chairs: Barbara Benassi & Bennett Ibey**

**S08-1 [12:00]**

**50-Hz magnetic field impairs the expression of iron-related genes in the *in vitro* SOD1<sup>G93A</sup> model of amyotrophic lateral sclerosis**

Claudia Consales<sup>1</sup>, Martina Panatta<sup>2</sup>, Alessio Butera<sup>3</sup>, Giuseppe Filomeni<sup>4</sup>, Caterina Merla<sup>1</sup>, Carmela Marino<sup>1</sup> & Barbara Benassi<sup>1</sup>

<sup>1</sup>*Division of Health Protection Technologies, ENEA, Rome, Italy, 00123*

<sup>2</sup>*Department of Chemistry and Biochemistry, University of Bern, Bern, Switzerland, 3012*

<sup>3</sup>*Department of Biology, University of Rome Tor Vergata, Rome, Italy, 00133*

<sup>4</sup>*Cell Stress and Survival Unit, Danish Cancer Society Research Center, Copenhagen, Denmark, 2100*

**Keywords: In vitro, ELF/LF, Completed (published)**

**Presented by: Claudia Consales**

We characterized the response to the extremely low frequency magnetic field (ELF-MF) in an *in vitro* model of Amyotrophic Lateral Sclerosis, carrying two mutant variants of the superoxide dismutase 1 (SOD1) gene. SH-SY5Y human neuroblastoma cells, stably over-expressing the wild type, the G93A or the H46R mutant SOD1 cDNA, were exposed to either the ELF-MF (50 Hz, 1 mT) or the sham control field, up to 72 hours. We report that 50-Hz MF exposure does not induce any change in proliferation and viability, but triggers a significant deregulation in the expression of iron-related genes IRP1, MFRN1 and TfR1, this evidence being exclusive for the SOD1<sup>G93A</sup> clone and associated with a slight (P=0.0512) difference in the total iron content.

**S08-2 [12:15]**

**50 Hz magnetic field exposure modulates Nitric Oxide Synthase 2 (NOS2) expression in N9 microglia cells**

Barbara Benassi<sup>1</sup>, Caterina Merla<sup>1</sup>, Claudia Consales<sup>1</sup>, Flavia Novelli<sup>1</sup>, Roberta Vitali<sup>1</sup>, Carmela Marino<sup>1</sup> & Claudio Pioli<sup>1</sup>

<sup>1</sup>*Division of Health Protection Technologies, ENEA, Rome, Italy, 00123*

**Keywords: In vitro, ELF/LF, Work in Progress**

Thessaloniki, Thessaloniki, Greece

<sup>3</sup>Swiss Federal Institute of Technology (ETHZ),  
Zurich, Switzerland, 8092

**Keywords: Standards, RF/Microwaves,  
Completed (published)**

**Presented by: Niels Kuster**

Exposure safety frameworks have been proposed for EM fields at frequencies above 6GHz. This study investigates whether the proposed limits are consistent with the goal of preventing potentially hazardous local heating. The results demonstrate that in the case of short pulses, duration-independent limits imposed on transmitted energy density (fluence) alone cannot preclude the induction of high skin temperature increases. Pulse-duration-independent fluence-limits are not suitable. They should either be replaced by duration-dependent ones or by limits on the peak exposure. The limits should be set considering narrow exposures. The current maximum averaging area should be replaced by a continuously frequency-dependent one.

### **S07-3 [12:30]**

#### **Safety concerns for MRI heating of fractured and adjacent metallic implants**

Manuel Murbach<sup>1</sup>, Nassim Nasser<sup>1</sup>, Esra Neufeld<sup>1</sup>  
& Niels Kuster<sup>1, 2</sup>

<sup>1</sup>IT'IS Foundation, Zurich, Switzerland, 8004

<sup>2</sup>ETH Zurich, Zurich, Switzerland, 8092

**Keywords: Dosimetry (computational),  
RF/Microwaves, Completed (published)**

**Presented by: Manuel Murbach**

Test methods for safety assessment regarding radiofrequency (RF) heating of small metallic medical implants in magnetic resonance imaging (MRI) are standardized by ASTM. The test is focused on individual or electrically connected implant systems; non-electrically connected combinations of fractured or multiple adjacent implants, which have not yet been sufficiently investigated, may lead to considerably altered RF coupling. In this study, we assessed induced heating as a function of the separation distance between two simple metal rods. Results show that the fracture or gap can shift the resonance frequency of the entire implant and may lead to 10-fold higher heating than an electrically connected implant of the same length.

**Presented by: Barbara Benassi**

The characterization of microglia response to electro-magnetic stimulation is a challenging field of research, as experimental results are still limited. With the aim to assess the effect driven by the extremely low frequency magnetic fields (ELF-MFs), we exposed the N9 mouse microglia cells to 50 Hz (1 mT) MF for 24 h, followed by 24 h treatment with the lipopolysaccharide(LPS). We found that ELF exposure was not toxic to cells, as both proliferation and viability were not affected by the radiation; conversely, the expression of NOS2 gene was stimulated by the ELF exposure. The characterization of the NOS2-mediated pathway and its impact on functional features of microglia cells is ongoing.

### **S08-3 [12:30]**

#### **STUDENT PAPER**

#### **The duration of 50-Hz extremely low frequency magnetic field pre-exposure affects the repair rate of bleomycin-induced DNA damage in murine FDC-P1 hematopoietic cells**

Ehab Mustafa<sup>1</sup>, Jukka Luukkonen<sup>1</sup> & Jonne Naarala<sup>1</sup>

<sup>1</sup>Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, Finland, 70211

**Keywords: In vitro, ELF/LF, Work in Progress  
Presented by: Ehab Mustafa**

According to current understanding, the disruption of circadian rhythm may lead to carcinogenesis by impairing the DNA damage responses. This association motivated us to explore whether the duration of exposure to extremely low frequency (ELF) magnetic fields (MFs) plays a role in the response to subsequent chemical treatment. We found that pre-exposure to 24-h and 48-h ELF MFs (50 Hz, 200  $\mu$ T) modified the repair rate of bleomycin-induced DNA damage in murine FDC-P1 hematopoietic cells, while no consistent effects were detected after 15-min or 2-h MF exposure durations. To identify the underlying mechanisms of the observed effects, we are currently performing gene expression analyses of the circadian rhythm and DNA damage responses.

**S07-4 [12:45]****Assessment of average power density definitions in free space using real mm-Waves antennas and devices**

Walid El Hajj<sup>1</sup>, Khodor Rida<sup>1</sup>, John Roman<sup>2</sup> & Nawfal Asrih<sup>1</sup>

<sup>1</sup>*Wireless RF Lab (WRF), iCDG , Intel Corporation, Antibes, France, 06600*

<sup>2</sup>*Government, Markets, and Trade (GMT), Intel Corporation, Hillsboro , Oregon, USA, 97124*

**Keywords: Standards, RF/Microwaves, Other**  
**Presented by: Walid El Hajj**

This paper shows a comparison between the two candidates for the definition of power density: 1) the normal component of Poynting vector crossing the surface, 2) the norm of Poynting Vector. We illustrate the difference as the ratio between the averaged power density values obtained using both definitions (1)/ (2). The ratio between 0 and 1 is studied for different source types and different distances from the sources. It shows that the ratio in can go from 56% to 98% depending on the distance, source type, and the EM environment around the antenna when integrated into device.

**S08-4 [12:45]****EGFR-mediated activation of MAPK signaling in human neuroblastoma cells exposed to weak, power-frequency magnetic field**

Maria Martinez<sup>1</sup>, Alejandro Ubeda<sup>1</sup> & Maria Angeles Trillo<sup>1</sup>

<sup>1</sup>*Investigación-BEM, Hosp. Universitario Ramón y Cajal-IRYCIS, Madrid, Spain, 28034*

**Keywords: In vitro, ELF/LF, Completed (unpublished)**

**Presented by: Maria Angeles Trillo**

The involvement of the EGFR receptor in the previously reported proliferation and activation of MAPK (-ERK1/2, -p38 and -JNK) in NB69 cells was investigated. The results confirmed that MF-exposure induces proliferation and activation of MAPK, and showed that these effects were blocked with erlotinib. The data also showed that, exposure induces increases in the expression of MMP-9 and p-EGFR at 5 and 15 min from the exposure onset, respectively. Together with our previously published results, these data suggest that the proliferative response induced in NB69 by a 63-hour exposure to a 100  $\mu$ T, power frequency MF, is mediated by early transient activation of EGFR potentially involving MMP-9.

**Lunch (not provided)**  
**Wednesday June 26, 2019 • 13:00 - 14:00**

**Thursday June 27, 2019**

**Session: DA  
d'Arsonval Award  
Thursday June 27, 2019 • 09:00 - 10:00  
Einstein  
Chair: Azadeh Peyman**

**DA-1 [09:00]**

**J. Patrick Reilly is the 2018 d'Arsonval Award winner**

J. Patrick Reilly<sup>1</sup>

<sup>1</sup>*Silver Spring, MD, USA*



The Bioelectromagnetics Society has a rigorous procedure to choose from outstanding nominations competing for the d'Arsonval Award. These nominations are initially carefully reviewed by members of the BEMS Awards Committee (composed of 5 board members and the last 5 d'Arsonval Award winners) before a recommendation is submitted to the Board of Director for the final vote.

It is an honour to announce that the Board of Directors of BEMS has supported the recommendation from the awards committee to give the d'Arsonval Award (2018) to J. Patrick Reilly in recognition of his outstanding achievements in Bioelectromagnetics Research.

Pat Reilly has been conducting bioelectromagnetics research for over 50 years, with over 160 published works, including 4 major text books. He first studied radar propagation at the Johns Hopkins University Applied Physics Laboratory beginning in 1965 when he was in graduate school. In the mid 70's, he started to investigate electrical influence on environment and people, and was a principle advisor to the Maryland State Department of Natural Resources providing biologically-based assessment of the electromagnetic effects of transmission lines across the electromagnetic spectrum. Since the early 80's, Pat Reilly has concentrated his focus on human sensitivity to electrical stimulation by contact currents and by induction from exposure to electric and magnetic fields. More recently he has been providing consulting work on the safety and effectiveness of electrical stun devices and electrical effects on astronauts during extravehicular activities.

Pat Reilly has provided invaluable service to the bioelectromagnetics community by serving on several standard-setting committees, and was the primary resource for technical development of IEEE Standard C95.6-2002, "IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz." His work as a consultant also influenced development and revision of guidelines prepared by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Reilly became a member of BEMS in 1983, and has been a participant on various BEMS working groups and program planning committees.

Pat Reilly's research, scholarly works, and extensive service to the bioelectromagnetics community at large, has been acknowledged and praised by several colleagues including previous winners of d'Arsonval award who submitted his nomination to BEMS awards committee.

Pat is also a keen Harmonica player and is known amongst colleagues and friends as the "Harmonica Guy"!

Many congratulations Pat!

**Session: S09**  
**Exposure assessment techniques I**  
**Thursday June 27, 2019 • 10:00 - 11:30**  
**Barthez**  
**Chairs: Teruo Onishi & Joe Wiart**

**S09-1 [10:00]**  
**STUDENT PAPER**

**A wearable multi-band SAR<sub>wb</sub>-meter for RF dosimetry in indoor environments**

Reza Aminzadeh<sup>1</sup>, Arno Thielens<sup>1, 2</sup>, Luc Martens<sup>1</sup> & Wout Joseph<sup>1</sup>

<sup>1</sup>*Department of Information Technology, Ghent University/imec, Ghent, Belgium, 9052*

<sup>2</sup>*Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, California, USA, CA 94704*

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (unpublished)**  
**Presented by: Reza Aminzadeh**

In this paper we propose a novel wearable multi-band whole-body averaged specific absorption rate (SAR<sub>wb</sub>) meter calibrated in a reverberation chamber for radio-frequency (RF) dosimetry in an indoor diffuse environment. A novel concept of mass factor is introduced that enables direct and straightforward in-situ measurement of SAR<sub>wb</sub> from the received powers on textile antennas in different frequency bands. The proposed method does not require numerical simulations. The meter has a low measurement uncertainty in terms of combined 50% confidence interval of its mass factor below 4.1 dB. The proposed meter is validated using a tri-axial broadband antenna and a spectrum analyzer.

**S09-2 [10:15] - YOUNG SCIENTIST PAPER**

**A five-country study of microenvironmental electromagnetic fields using two personal exposimeters and a distributed body-worn sensor**

Marloes Eeftens<sup>1, 2</sup>, Reza Aminzadeh<sup>3</sup>, Stefan Dongus<sup>1, 2</sup>, Anke Huss<sup>4</sup>, Rene De Seze<sup>5</sup>, Patricia de Llobet<sup>6, 7</sup>, Matthias Van Den Bossche<sup>3</sup>, Elisabeth Cardis<sup>6, 7</sup>, Elodie Vauquelin<sup>8</sup>, Arno Thielens<sup>3</sup>, Patrick Van Torre<sup>3</sup>, Sam Agneessens<sup>3</sup>,

**Session: S10**  
**Interaction Mechanisms (theoretical and experimental)**  
**Thursday June 27, 2019 • 10:00 - 11:30**  
**Einstein**  
**Chairs: Frank S. Prato & Frank Barnes**

**S10-1 [10:00]**

**How genes from magnetotactic bacteria can transform magnetic resonance imaging into a powerful molecular imaging technology**

Frank S. Prato<sup>1, 2, 4, 5</sup>, Qin Sun<sup>1, 2</sup>, Cecile Fradin<sup>3</sup>, R. Terry Thompson<sup>1, 2, 5</sup> & Donna Goldhawk<sup>1, 2, 5</sup>

<sup>1</sup>*Lawson Imaging, Lawson Health Research Institute, London, Ontario, Canada, N6A 4V2*

<sup>2</sup>*Medical Biophysics, Western University, London, Ontario, Canada, N6A 3K7*

<sup>3</sup>*Physics and Astronomy, McMaster University, Hamilton, Ontario, Canada, L8S 4L8*

<sup>4</sup>*Physics and Astronomy, Western University, London, Ontario, Canada, N6A 3K7*

<sup>5</sup>*St. Joseph's Health Care, London, Ontario, Canada, N6A 4V2*

**Keywords: Clinical (diagnostics), Static, Completed (unpublished)**  
**Presented by: Frank Prato**

Optical reporter genes, such as firefly luciferase, are a powerful tool for imaging molecular activity in cells, tissues and small rodents. In larger animals and humans, a successful reporter gene is needed; one specific for magnetic resonance imaging (MRI) would be ideal. Magnetotactic bacteria produce iron particles of magnetite, which is the strongest MRI contrast agent known. Over the last decade, we have successfully introduced some of the needed magnetotactic bacterial genes into mammalian cells. As a proof of principle, weak MRI contrast has been achieved using only one such gene. More genetic engineering using additional bacterial genes to increase MRI contrast is currently being investigated.

**S10-2 [10:15]**  
**STUDENT PAPER**

**Collective oscillations of proteins proven by terahertz spectroscopy in aqueous medium**

Yoann Meriguet<sup>1, 2</sup>, Mathias Lechelon<sup>3, 4</sup>, Matteo Gori<sup>3</sup>, Ilaria Nardecchia<sup>3</sup>, Anastasiia Kudashova<sup>1</sup>, Dominique Coquillat<sup>2</sup>, Luca Varani<sup>1</sup>, Marco Pettini<sup>3</sup> & Jeremie Torres<sup>1</sup>

<sup>1</sup>*Institut d'Electronique et des Systèmes (IES), University of Montpellier, Montpellier, France*

Roel Vermeulen<sup>4, 9</sup>, Wout Joseph<sup>3</sup> & Martin Röösl<sup>1, 2</sup>

<sup>1</sup>Department of Environment and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland

<sup>2</sup>Department of Epidemiology and Public Health, Swiss Tropical & Public Health Institute, Basel, Switzerland

<sup>3</sup>Department of Information Technology (INTEC), Ghent University/imec, Ghent, Belgium

<sup>4</sup>Institute for Risk Assessment Sciences (IRAS), University of Utrecht, Ghent, Belgium

<sup>5</sup>TOXI/PERITOX UMRI-01, National Institute for Industrial Environment and Risks (INERIS), Verneuil-en-Halatte, France

<sup>6</sup>ISGlobal, Barcelona Institute for Global Health, Barcelona, Spain

<sup>7</sup>Pompeu Fabra University, Barcelona, Spain

<sup>8</sup>Technical Center for Mechanical Industries (CETIM), Senlis, France

<sup>9</sup>Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, the Netherlands

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (unpublished)**  
**Presented by: Marloes Eeftens**

We characterized exposure to RF-EMF in 357 different unique microenvironments in five European countries, using two personal exposimeters, as well as a vest with integrated sensors. We found substantial exposure differences between large cities, medium-sized towns and small villages, and found consistently higher total exposures in central, busy places with many people (business, shopping districts) than in quieter, residential areas.

### S09-3 [10:30]

#### Personal RF-EMF exposure from mobile phone base stations during populous temporary events

Raquel Ramírez-Vazquez<sup>1</sup>, Jesus Gonzalez-Rubio<sup>2</sup>, Enrique Arribas<sup>1</sup> & Alberto Nájera<sup>2</sup>

<sup>1</sup>Applied Physics, University of Castilla-La Mancha, Albacete, Spain, 02008

<sup>2</sup>Medical Sciences, University of Castilla-La Mancha, Albacete, Spain, 02008

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (unpublished)**  
**Presented by: Alberto Nájera**

Summary: Personal RF-EMF exposure from mobile phones (uplink) and mobile phone base stations (downlink) installed at the 2017 Albacete Fair

<sup>2</sup>Laboratoire Charles Coulomb (L2C), University of Montpellier, CNRS, Montpellier, France

<sup>3</sup>Centre de Physique Théorique (CPT), Aix-Marseille University, CNRS, Marseille, France

<sup>4</sup>Centre d'Immunologie de Marseille-Luminy (CIML), Aix-Marseille University, Marseille, France

**Keywords: Mechanistic/Theoretical, THz, Completed (published)**

**Presented by: Yoann Meriguet**

Understanding the forces that enable protein interaction is a major scientific challenge. Indeed, Brownian diffusion alone, which is usually considered as the main engine of protein dynamics, does not explain the rapidity and efficiency of the biomolecular reactions at work in cells. In this presentation we will present the first observation of the collective oscillations of a model protein driven out-of-equilibrium by means of optical excitation using terahertz spectroscopy.

### S10-3 [10:30]

#### STUDENT PAPER

#### D3M: A new pathway to magneto-sensitivity exemplified by lipid autoxidation

Robert H. Keens<sup>1</sup>, Chris Sampson<sup>1, 2</sup> & Daniel R. Kattnig<sup>1, 2</sup>

<sup>1</sup>Department of Physics, University of Exeter, Exeter, United Kingdom, EX4 4QD

<sup>2</sup>Living Systems Institute, University of Exeter, Exeter, United Kingdom, EX4 4QD

**Keywords: Mechanistic/Theoretical, Static, Completed (unpublished)**  
**Presented by: Robert H. Keens**

The Radical Pair Mechanism is a canonical model for the magnetosensitivity of chemical reactions. Its key ingredient is the hyperfine interaction that

(Spain) was recorded. Measurements were repeated on a weekday, at the weekend and the day after the Fair ended after temporary base stations had been removed. Installing mobile phone base stations, and a dense public using mobile phones, imply a significant increase in personal RF-EMF exposure compared to that recorded during normal periods in the same area. However, the recorded measurements were below legally established limits. Personal RF-EMF exposure from mobile phones (uplink) and mobile phone base stations (downlink) installed at the 2017 Albacete Fair (Spain) was recorded.

#### **S09-4 [10:45]**

##### **Comparing the accuracy of personal radiofrequency measurements using commercially available exposimeters with a novel body-worn measurement device**

Anke Huss<sup>1</sup>, Stefan Dongus<sup>2</sup>, Reza Aminzadeh<sup>3</sup>, Arno Thielens<sup>3, 5</sup>, Sam Agneessens<sup>3</sup>, Patrick Van Torre<sup>3</sup>, Rene De Seze<sup>4</sup>, Elisabeth Cardis<sup>6</sup>, Marloes Eeftens<sup>2</sup>, Wout Joseph<sup>3</sup>, Roel Vermeulen<sup>1</sup> & Martin Röösli<sup>2</sup>

<sup>1</sup>*Institute for Risk Assessment Sciences, Utrecht University, Utrecht, the Netherlands*

<sup>2</sup>*Swiss Tropical and Public Health Institute, University of Basel, Basel, Switzerland*

<sup>3</sup>*Department of Information Technology/ IMEC, Ghent, Belgium*

<sup>4</sup>*TOXI/PERITOX UMR I-01, National Institute for Industrial Environment and Risks, Verneuil-en-Halatte, France*

<sup>5</sup>*Berkeley Wireless Research Center, Berkeley, CA, USA*

<sup>6</sup>*Barcelona Institute for Global Health, Barcelona, Spain*

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (published)**  
**Presented by: Anke Huss**

We developed a new RF-EMF meter with sensors distributed over the front and back side of a vest, performed measurements in different microenvironments in five countries and compared results with commercially available exposimeters that are frequently used in epidemiological studies.

#### **S09-5 [11:00]**

##### **A comparison between a measured and modelled assessment of the EMF exposure compliance boundary of an in-situ massive MIMO 4G LTE mobile radio base station**

induces a coherent mixing of singlet and triplet electron spin states in pairs of radicals, thereby facilitating magnetic field effects (MFEs) on reaction yields. We have developed an alternative model, dubbed D3M, that demonstrates that the hyperfine interaction is not a categorical requirement to realize the sensitivity of radical reactions to weak magnetic fields. In systems comprising three instead of two radicals, dipolar interactions provide an alternative pathway for biologically relevant MFEs. We will apply these new ideas to the putative magnetosensitivity of lipid peroxidation.

#### **S10-4 [10:45]**

##### **Membrane receptor-mediated ROS generation upon ELF exposure in neuroblastoma cells: an experimental and computational study**

Caterina Merla<sup>1</sup>, Micaela Liberti<sup>2</sup>, Claudia Consales<sup>1</sup>, Agnese Denzi<sup>2</sup>, Francesca Apollonio<sup>2</sup>, Carmela Marino<sup>1</sup> & Barbara Benassi<sup>1</sup>

<sup>1</sup>*ENEA, Division of Health Protection Technologies, Rome, Italy, 00123*

<sup>2</sup>*Department of Information Engineering, Electronic, and Telecommunications, Sapienza University, Rome, Italy, 00184*

**Keywords: Mechanistic/Theoretical, ELF/LF, Completed (unpublished)**  
**Presented by: Caterina Merla**

In this work, the role of NADPH oxidase (Nox1) in ELF-MF mediated ROS generation is investigated. To this aim, we treated SH-SY5Y human neuroblastoma cells with the DPI, prior to exposure to 50 Hz, 1 mT MF for 24 hours. To locally quantify electric quantities and verify their biological relevance in the different cell compartments, microscopic electric fields and current densities in the surroundings of the plasma membrane of single cells have been computed. Our microdosimetric evaluations support experimental data demonstrating that a membrane receptor as Nox1 can be activated by the induced level of local current densities, thus indicating the membrane/extra-cellular medium interface as preferential target for ELF-neuron interactions.

#### **S10-5 [11:00]**

##### **WITHDRAWN**

Rob Werner<sup>1</sup> & Phillip Knipe<sup>2</sup>

<sup>1</sup>*Network Governance, Singtel Optus, Brisbane, Australia, 4017*

<sup>2</sup>*Total Radiations Solutions Pty Ltd, Perth, Australia*

**Keywords: Dosimetry (measurements),**

**RF/Microwaves, Work in Progress**

**Presented by: Rob Werner**

Determining the realistic electromagnetic field (EMF) compliance boundary around a mobile phone base station antenna that utilizes beam forming massive multiple input multiple output (mMIMO) technology presents a challenge for mobile operators. Typically, compliance boundaries computed using a 'worst case' approach leads to a significant over estimation of realistic, everyday EMF levels. In this paper we show that in situ measurements of EMFs from an LTE 4G beam forming multi-user mMIMO antenna in a high mobile traffic urban environment are up to 12 dB lower than levels computed using a 'worst case' approach. In this high mobile traffic urban environment, the 'worst case' measurement was 7.3% of computed maximum level.

#### **S09-6 [11:15]**

##### **STUDENT PAPER**

##### **Personal RF-EMF exposure levels in five Belgian cities**

Maarten Velghe<sup>1</sup>, Wout Joseph<sup>1</sup>, Senne Debouvere<sup>1</sup>, Reza Aminzadeh<sup>1</sup>, Luc Martens<sup>1</sup> & Arno Thielens<sup>1, 2</sup>

<sup>1</sup>*Department of Information Technology, Ghent University/IMEC, Ghent, Belgium, 9052*

<sup>2</sup>*Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, California, USA, 94704*

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (unpublished)**

**Presented by: Maarten Velghe**

We characterized personal exposure to radio frequency-electromagnetic fields in 5 of the largest cities in Belgium using body-worn personal exposimeters. We related exposure to population density, regulatory limits, and time (rush and non-rush hours). The median values for total exposure showed a high repeatability and representativeness ( $r=0.95$  and  $r=0.88$  respectively). The highest average total exposure was found in Brussels (2.63 mW/m<sup>2</sup>). However, higher average downlink exposure was observed in a less densely populated city than Brussels. This might for the first time indicate an effect of the more stringent regulatory

#### **S10-6 [11:15]**

##### **Is tubulin a sensitive target of nanosecond-scale intense electric field? A molecular dynamics study**

Paolo Marracino<sup>1</sup>, Daniel Havelka<sup>2</sup>, Jiří Průša<sup>2</sup>, Micaela Liberti<sup>1</sup>, Jack A. Tuszynski<sup>3</sup>, Ahmed T. Ayoub<sup>4</sup>, Francesca Apollonio<sup>1</sup> & Michal Cifra<sup>2</sup>

<sup>1</sup>*Information Engineering, Electronics and Telecommunications, University of Rome Sapienza, Rome, Italy, 00184*

<sup>2</sup>*Institute of Photonics and Electronics o, Czech Academy of Sciences, Prague, Czech Republic, 18200*

<sup>3</sup>*DIMEAS, Politecnico di Torino, Torino, Italy, 10129*

<sup>4</sup>*Medicinal Chemistry Department, Heliopolis University, Cairo, Egypt, 11777*

**Keywords: Mechanistic/Theoretical, Pulsed, Completed (unpublished)**

**Presented by: Jack A. Tuszynski**

Intense pulsed electric fields are known to act at the cell membrane level and are already being exploited in biomedical and biotechnological applications. However, it is not clear if intra-cellular components such as cytoskeletal proteins could be directly influenced by electric pulses within biomedically-attainable parameters. Our results with molecular dynamics on a tubulin heterodimer, suggest that intense nanosecond electric pulses

limits on outdoor exposure levels in Brussels.

could be used for physical modulation of microtubule dynamics. Since nanosecond pulsed electric field can penetrate cellular membranes due to its broadband spectrum, our results are also potentially significant for the development of novel therapeutic protocols.

**Coffee Break**  
**Thursday June 27, 2019 • 11:30 - 12:00**  
**Joffre 2-3**

**Session: P4**  
**Plenary 4 - Can membrane proteins act as biological probes for EM fields?**  
**Thursday June 27, 2019 • 12:00 - 13:00**  
**Einstein**  
**Chairs: Olga Pakhomova & Olga Zeni**

**P4-1 [12:00]**

**Can membrane proteins act as biological probes for EM fields?**

Francesca Apollonio<sup>1</sup>

<sup>1</sup>*Information Engineering, Electronics and Telecommunications, University of Rome Sapienza, Rome, Italy, 00184*



#### **Biographical sketch**

Francesca Apollonio received the Doctorate degree from the Sapienza University of Rome, Rome, Italy, 1998. Since 2000, she joined the Department of Electronic Engineering, Sapienza University of Rome as Assistant Professor and since 2019 she is Associate Professor. Dr. Apollonio is a member of the National Scientific Commission CNR-URSI, Commission K “Electromagnetics in Biology and Medicine” since 2011. From 2012 to 2015, she served on the Board of Directors of the Bioelectromagnetic Society. Presently she is National Representative of COST CA15211, “Atmospheric Electricity Network: coupling with the Earth System, climate and biological systems”.

Her current research interests include the interaction between electromagnetic fields and biological systems using both theoretical and

experimental approaches.

#### **Abstract**

Membrane proteins are incorporated in the lipid bilayer of cells and allow signal transduction and transport of ligand molecules across the membrane. Because of these functions membrane proteins are the gatekeepers of cellular membranes where they act as enzymes, transporters, signaling receptors, or in energy conversion. In view of the role that they have on the sensory systems of living organisms when detecting and responding to various environmental stimuli, they can be also considered a probe for electromagnetic (EM) fields. Therefore in the present lecture starting from literature data supporting an involvement of membrane proteins as target for electric/magnetic or electromagnetic field, an attempt to unify the mechanism of interaction with EM fields will be provided, making use of computational techniques based on molecular dynamics (MD) simulations. MD simulations offer a great and distinct approach to investigate the structure of membrane proteins in ways that are complementary to experimental procedures. Due to the recent evolutions in computational efficiency, MD simulations have become a valuable tool for characterizing the organizational principles of cell membranes, for investigating the ligand-binding process and for elucidating mechanisms of interaction between electric and/or magnetic field and membrane proteins.

## Adenosine receptors as pathways for beneficial effects of pulsed electromagnetic fields

Fabrizio Vincenzi<sup>1</sup> & Simona Salati<sup>2</sup>

<sup>1</sup>Pharmacology and Toxicology, University of Ferrara, Ferrara, Italy, 44121

<sup>2</sup>IGEA S.p.A., Carpi, Italy



### Biographical sketch

Fabrizio Vincenzi is a researcher and lecturer of Pharmacology and Toxicology at the University of Ferrara, Italy. His research activity is in the field of membrane receptors, with a specific interest in adenosine receptors and their involvement in different pathologies at both the central and peripheral level. The objectives of his works are to understand the mechanisms of membrane receptor modulation in response to pathological states and chemical or physical stimuli. He dedicated part of his research activity to the interaction between pulsed electromagnetic fields and adenosine receptors investigating how adenosine receptor could represent a biological pathway for the observed effects of pulsed electromagnetic fields. Fabrizio Vincenzi received his Bachelor's degree in Biology and a PhD in Pharmacology and Molecular Oncology at the University of Ferrara, on studies of the role of adenosine receptors in Huntington's disease. He carried out his postdoctoral research in the group directed by Professor

Pier Andrea Borea and Professor Katia Varani at the Institute of Pharmacology, Department of Medical Sciences of the University of Ferrara. He is author of 85 papers, various book chapters and co-editor of a recent book on adenosine receptors edited by Springer for the series "The Receptors". He is a member of the Italian Society of Pharmacology and Italian Purine Club.



### Biographical sketch

Simona Salati received her Doctorate degree in Biotechnology and Molecular Medicine in 2004 from the University of Modena and Reggio Emilia. Her postdoctoral training was carried on in the lab directed by Dr. Bhatia, at the Stem Cell and Cancer Research Institute, Canada. Her research activity has been focused on the study of the molecular mechanisms regulating self-renewal and differentiation of normal and leukemic hematopoietic stem cells. She is currently research coordinator of pre-clinical studies at IGEA, Italy. Her research interest is now focused on the study of effects exerted by pulsed electromagnetic fields on biological systems, such as bone, articular cartilage and neurons.

She is author of 29 papers.

### Abstract

The beneficial therapeutic effects of pulsed electromagnetic field (PEMF) have been documented with increasing frequency over the last decades. PEMF stimulation therapies have been clinically successful in treating a variety of medical conditions, including expedited healing of non-union long bone fractures and arrested progression of osteoarthritis. One of the most prominent features of PEMF therapy is to protect the articular micro environment from inflammation and degeneration processes. The molecular and cellular effects of PEMF exposure on pathways involved in the resolution of inflammation are a subject of intense investigations. In the attempt to clarify the mechanisms that underpin the beneficial effect of PEMF, we focused on membrane receptors a potential link between physical stimulation and biological response. In the last two decades, we collected numerous evidence that allowed us to identify adenosine receptors as candidates for the biological pathways of the anti-inflammatory and protective effect of PEMF. Adenosine has been reported to be a potent immunomodulatory agent, with reports of receptor activation on varied cells curtailing exuberant inflammatory responses. Of the four G-protein-coupled receptors, PEMF specifically influence A<sub>2A</sub> and A<sub>3</sub> subtypes, enhancing the anti-inflammatory and protective functions of adenosine.

In this talk, I will discuss how PEMF exposure affects membrane protein functions and the data indicating adenosine receptors as a biological pathway for the cellular and molecular effects of PEMF.

**Lunch**  
**Thursday June 27, 2019 • 13:00 - 14:30**  
**Joffre 1**

**Session: M4**  
**BEMS Assembly**  
**Thursday June 27, 2019 • 13:30 - 14:30**  
**Barthez**

**Session: S11**  
**Dosimetry of ELF/LF fields**  
**Thursday June 27, 2019 • 14:30 - 16:00**  
**Einstein**  
**Chairs: Philippe Leveque & Kenichi Yamazaki**

**Session: S12**  
**Electroporation Studies and Effects of Pulsed Electric Fields**  
**Thursday June 27, 2019 • 14:30 - 16:00**  
**Barthez**  
**Chairs: Lluís M. Mir & P. Thomas Vernier**

**S11-1 [14:30]**  
**STUDENT PAPER**

**Computational errors of the induced electric field in voxelized and tetrahedral anatomical head models exposed to spatially uniform magnetic field**

Marco Soldati<sup>1</sup> & Ilkka Laakso<sup>1</sup>

<sup>1</sup>*Department of Electrical Engineering and Automation, Espoo, Finland*

**Keywords: Dosimetry (computational), ELF/LF, Completed (published)**

**Presented by: Marco Soldati**

The magnitude of the induced electric field is used as the dosimetric quantity for human protection at low frequencies. To compute the induced electric field, numerical methods based on voxel models are used, which introduce staircasing approximation errors. By contrast, those artifacts are absent in case of tetrahedral meshes. The 99th percentile of the induced electric field is recommended in the ICNIRP guidelines to remove computational artifacts. Here, the electric fields induced by uniform magnetic field exposure at 50 Hz were evaluated using two computational methods based on cubical and tetrahedral elements, respectively. The purpose is to evaluate how the 99th, 99.9th and 99.99th percentiles depend on the meshing approach.

**S12-1 [14:30]**

**Microdosimetric realistic model of cell with endoplasmic reticulum under the action of nanosecond pulses**

Annalisa De Angelis<sup>1</sup>, Agnese Denzi<sup>1</sup>, Caterina Merla<sup>2</sup>, Franck Andre<sup>3</sup>, Tomás García-Sánchez<sup>3</sup>, Lluís M. Mir<sup>3</sup>, Francesca Apollonio<sup>1</sup> & Micaela Liberti<sup>1</sup>

<sup>1</sup>*ICEmB at Department of Information Engineering, Electronics and Telecommunications, University of Rome Sapienza, ROMA, Italy, 00184*

<sup>2</sup>*SSPT-Division of Health Protection Technologies, ENEA, ROMA, Italy, 00123*

<sup>3</sup>*Vectorology and Anticancer Therapies-UMR 8203 CNRS, Univ. Paris-Sud, Université Paris-Saclay, Villejuif, France, 94805*

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Annalisa De Angelis**

With the aim to investigate the biophysical effects induced by a high intensity electric field on a biological cell at cellular and subcellular level, authors present a microdosimetric study based on a 2D realistic model of a cell and its endoplasmic reticulum. The microdosimetric analysis of the cell and endoplasmic reticulum was quantified in terms of electric field and transmembrane potential induced by an externally applied high amplitude 10-ns pulsed electric field. In addition, electroporated local membrane sites and pore densities were also evaluated. This study opens the way to numerically assist experimental applications of nanosecond pulsed electric fields for controlled bio-manipulation of cells and subcellular organelles.

**S11-2 [14:45]**  
**STUDENT PAPER**

**The risk of cardiac ventricular fibrillation in humans due to body currents of frequencies up to 100 kHz determined by the use of computational pig models**

Pia Schneeweiss<sup>1</sup>, Kai Jagielski<sup>1</sup>, Dominik Stunder<sup>1</sup>, Tobias Theiler<sup>1</sup> & Thomas Kraus<sup>1</sup>

<sup>1</sup>Research Center for Bioelectromagnetic Interaction (femu), RWTH Aachen University, Aachen, Germany, 52074

**Keywords: Dosimetry (computational), All Frequencies, Work in Progress**  
**Presented by: Pia Schneeweiss**

According to the German Social Accident Insurance Institution (BG ETEM), 88% of the 3463 reported occupational electricity accidents in 2016 were in the low-voltage sector (AC < 1 kV or DC < 1.5 kV), whereof five victims died. One of the most common causes of death in this voltage range is ventricular fibrillation, which shows itself in a very rapid and uncontrolled contraction and relaxation of the heart. In order to take successful preventive measures, it is essential to determine the body currents that induce ventricular fibrillation. Therefore, we compare the data of published in vivo animal studies with numerical simulations of animals and humans. We present the preliminary data as well as the future planned work.

**S11-3 [15:00]**  
**STUDENT PAPER**

**Stochastic dosimetry applied for the assessment of children exposure variability to near-field sources in the ELFSTAT project**

Marta Bonato<sup>1, 2</sup>, Emma Chiamarello<sup>1</sup>, Serena Fiocchi<sup>1</sup>, Gabriella Tognola<sup>1</sup>, Marta Parazzini<sup>1</sup> & Paolo Ravazzani<sup>1</sup>

<sup>1</sup>Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni, Consiglio Nazionale delle Ricerche, Milano, Italy, 20133

<sup>2</sup>Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Milano, Italy, 20133

**Keywords: Dosimetry (computational), ELF/LF, Completed (unpublished)**  
**Presented by: Marta Bonato**

The work is performed in the context of the ELFSTAT project, which aims at characterizing children's exposure to ELF-MF in real exposure scenarios using stochastic approaches. Since also domestic appliances could be relevant for children

**S12-2 [14:45]**

**Calcium ion activation by nanoporation and opening of voltage-gated calcium channels by nanosecond pulsed electric field**

Olga Pakhomova<sup>1</sup>, Uma Mangalanathan<sup>1</sup>, Kiril Hristov<sup>1</sup>, Maura Casciola<sup>1</sup>, Shu Xiao<sup>1</sup> & Andrei Pakhomov<sup>1</sup>

<sup>1</sup>Frank Reidy Research Center for Bioelectrics, Old Dominion University, Norfolk, Virginia, USA, 23508

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Olga Pakhomova**

Our data indicate that direct activation of voltage-gated calcium channels (VGCC) by short 300-ns PEF stimuli is possible, although the thresholds for VGCC stimulation and electroporation are very close.

**S12-3 [15:00]**

**Evaluation of membrane potential changes induced by oscillating nanosecond duration electric fields**

Bennett Ibey<sup>1</sup>, Caleb Roth<sup>1</sup>, Ronald Barnes<sup>1</sup> & Hope Beier<sup>1</sup>

<sup>1</sup>Air Force Research Laboratory, Fort Sam Houston, Texas, USA, 78234

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Bennett Ibey**

INTRODUCTION Recently, we pioneered a new imaging system called a streak camera microscope (SCM) that is able to resolve sub nanosecond membrane potential changes in cells loaded with FluoVolt dye<sup>1</sup>. This technique opens the window into the response of cell membrane potential to rapidly applied electric fields. Having demonstrated this response on single bipolar and unipolar electric pulses, we have begun to investigate the rapid charging and discharging of the plasma membrane during bursts of alternating current (AC) frequencies. We believe that understanding the dynamics of plasma membrane charging during AC

level exposure, this work aims to assess the exposure variability due to near-field sources, not limiting it only on worst-case exposure scenario. In this paper the child exposure to a hairdryer model is evaluated using a stochastic dosimetry approach based on Polynomial Chaos theory (PC). The electric field amplitudes induced in specific tissues composing the CNS and the PNS were analyzed. The results highlight a high exposure variability depending on source position in respect with the child head.

#### **S11-4 [15:15]**

##### **Unsupervised Machine Learning techniques for the characterization of children exposure to ELF MF**

Gabriella Tognola<sup>1</sup>, Marta Bonato<sup>1</sup>, Emma Chiaramello<sup>1</sup>, Serena Focchi<sup>1</sup>, Isabelle Magne<sup>2</sup>, Martine Souques<sup>2</sup>, Marta Parazzini<sup>1</sup> & Paolo Ravazzani<sup>1</sup>

<sup>1</sup>*Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni, Consiglio Nazionale delle Ricerche, Milan, Italy, 20133*

<sup>2</sup>*EDF, Levallois-Perret, France*

**Keywords: Dosimetry (measurements), ELF/LF, Completed (unpublished)**

**Presented by: Gabriella Tognola**

In this study we characterized children exposure to extremely low frequency (ELF) magnetic fields using cluster analysis – a Machine Learning approach. Indoor personal exposure measurements from 977 children in France were analyzed to discover how electric networks near child home or school could influence exposure patterns. 225 kV/400 kV overhead lines characterized the cluster of children with the highest exposure; 63 kV/150 kV overhead lines characterized the cluster with mid-to-high exposure; 400 V/20 kV substations and underground networks characterized mid-to-low exposures. 400 V/20 kV overhead lines and 63-225 kV underground networks had a marginal contribution in differentiating and characterizing the exposure clusters.

#### **S11-5 [15:30]**

##### **STUDENT PAPER**

##### **Measurement and health assessment of electromagnetic fields by electric vehicles during road traffic operation using driving characteristics**

Kai Jagielski<sup>1</sup>, Pia Schneeweiss<sup>1</sup> & Thomas Kraus<sup>1</sup>

<sup>1</sup>*Research Center for Bioelectromagnetic*

pulses will better inform those using such pulses to modify cell physiology<sup>2</sup>.

#### **S12-4 [15:15]**

##### **STUDENT PAPER**

##### **Low-intensity nanosecond pulsed electric field exposure modulates adenosine triphosphate *in vitro***

Hollie Ryan<sup>1, 2, 3</sup>, Bennett Ibey<sup>3</sup> & Caleb Roth<sup>3</sup>

<sup>1</sup>*Biomedical Engineering, Old Dominion University, Norfolk, Virginia, USA, 23529*

<sup>2</sup>*Frank Reidy Research Center for Bioelectrics, Old Dominion University, Norfolk, Virginia, USA, 23529*

<sup>3</sup>*711 Human Performance Wing, Air Force Research Laboratory, San Antonio, Texas, USA, 78234*

**Keywords: Electrochemistry, Pulsed, Completed (unpublished)**

**Presented by: Hollie Ryan**

Nanosecond pulsed electric fields have been shown to stimulate intracellular calcium release, with corresponding rates of cell survival higher when the incident pulse is bipolar vs. unipolar. NsPEF effects on wider intracellular processes, however, are not fully understood. This *in vitro* study focused on adenosine triphosphate (ATP), the complex organic chemical that provides the energy to drive many processes in living cells. Results indicate that electric field strength, pulse polarity and cell type all play a role in the differential modulation of nanosecond pulse stimulation of ATP synthesis and release of ATP into the extracellular environment.

#### **S12-5 [15:30]**

##### **Direct effects of nanosecond-scale electric field on tubulin**

Djamel E. Chafai<sup>1</sup> & Michal Cifra<sup>1</sup>

<sup>1</sup>*Bioelectrodynamics research team, Institute of Photonics and Electronics of the Czech Academy of Sciences, Prague, Czech Republic, 18200*

**Keywords: Mechanistic/Theoretical, Pulsed,**

*Interaction (femu), RWTH Aachen University, Aachen, Germany, 52074*

**Keywords: Dosimetry (measurements), Pulsed, Work in Progress**

**Presented by: Kai Jagielski**

Electromagnetic field measurements in the frequency range between 1 Hz and 400 kHz were performed on five purely electrically operated passenger cars. The additional recording of the driving style, with acceleration sensor and GPS module, allows a detailed investigation of the influence of various vehicle components on the magnetic field spectrum. First measurements show that the maximum exposures assessed with ICNIRP 2010 gen. pub. are not to be found at standardized measuring points at the seats, but often in the footwell or along the back seat. Sharp switching flanks are found during switching processes and charging, which partly exceed the limit values. First measurement results of the Tesla Model S will be shown at the BioEM 2019.

#### **S11-6 [15:45]**

##### **Mitigation of LF magnetic fields generated by welding guns**

Luca Giaccone<sup>1</sup>, Vincenzo Cirimele<sup>1</sup> & Aldo Canova<sup>1</sup>

<sup>1</sup>*Dipartimento Energia "G. Ferraris", Politecnico di Torino, Torino, Italy, 10129*

**Keywords: Dosimetry (computational), Pulsed, Completed (published)**

**Presented by: Luca Giaccone**

Among the different welding technologies, portable welding guns are one of the most critical devices in relation to human exposure to electromagnetic fields. This paper focuses on medium frequency direct current guns proposing an effective solution to mitigate the predominant magnetic field that is generated by the electrodes of the welding gun. The analysis of the field waveforms shows that the rise time of the welding current pulse is the main parameter affecting the exposure index. The effect of the increase of the rise time is investigated through experimental and numerical analyses. The results prove that a small increase of the rise time causes a significant reduction of the exposure level.

#### **Completed (unpublished)**

**Presented by: Michal Cifra**

We experimentally demonstrate in vitro direct effects of intense (20 kV/cm), pulsed electric field (100 – 800 pulses, 1 Hz, 10 ns pulse width) – nsPEF - on tubulin capacity of self-assembly into microtubules – structures crucial for cell division and intracellular transport. We used multiple complementary assays (turbidimetry, autofluorescence, and zeta potential assay) and atomic force microscopy to show that tubulin structure and an effective charge is affected in a dose-dependent manner, which leads to a perturbation of its polymerization capability into microtubules. Our results demonstrate that nsPEF can directly modulate tubulin function in vitro hence bringing insights into nsPEF biological effects.

#### **S12-6 [15:45]**

##### **Simulation and *in-vitro* study of nanosecond electric pulse width effect on cancer cells**

Xin Rao<sup>1</sup>, Xiaodong Chen<sup>1, 3</sup>, Jun Zhou<sup>1</sup> & Yiyao Liu<sup>2</sup>

<sup>1</sup>*School of Electronic Science and Engineering, University of Electronic Science and Technology of China, Chengdu, China, 610054*

<sup>2</sup>*School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu, China, 610054*

<sup>3</sup>*School of Electronic Engineering and Computer Science, Queen Mary University of London, London, United Kingdom, E1 4NS*

**Keywords: In vitro, Pulsed, Completed (unpublished)**

**Presented by: Xiaodong Chen**

Nanosecond pulsed electric fields (nsPEF) have been shown to induce cancerous cell death and cause the remission of tumors in animals. In most of these studies, a fixed pulse width generator is adopted and the effect of pulse width is not clearly. Therefore, this paper presents our investigation into the pulse width effect when nsPEF interacting with cancer cells through electromagnetic (EM) simulation and in-vitro experiments. Our study shows that nsPEF with different pulse width interacts with the cell structure in a different manner and induces different proportion of cell apoptosis.

**Coffee Break**  
**Thursday June 27, 2019 • 16:00 - 16:30**  
**Joffe 2-3**

**Session: W3**  
**Workshop 3 - Dosimetric aspects in exposure assessment to wireless power transfer systems**  
**Thursday June 27, 2019 • 16:30 - 18:00**  
**Einstein**  
**Chairs: Teruo Onishi & Rosanna Pinto**

**Session: W4**  
**Workshop 4 - Toward an innovative use of ultrashort electric pulses in medicine: From biological effects to therapeutic applications**  
**Thursday June 27, 2019 • 16:30 - 18:30**  
**Barthez**  
**Chairs: Claudia Consoles & Lluís M. Mir**

**W3-1 [16:30]**

**Standardization activities of exposure assessment methods for Wireless Power Transfer (WPT)**

Teruo Onishi<sup>1</sup> & Kanako Wake<sup>2</sup>

<sup>1</sup>*NTT DoCoMo, Inc., Yokosuka, Japan, 2398536*

<sup>2</sup>*National Institute of Information and Communications Technology, Koganei, Japan, 1848795*

Standardization activities of exposure assessment methods for Wireless Power Transfer (WPT) are introduced. Recently WPT systems are getting popular for mobile terminals, Electric Vehicle (EV), and etc. over the world, however there is no standardized exposure assessment methods for WPT systems. Therefore International Electrotechnical Committee (IEC) TC106 established a working group (WG9) investigating the exposure assessment methods for WPT systems in 2015. After that TC106 established a new project, PT63184 to standardize a basic exposure assessment method based on TR62905 while the WG9 focuses on microwave WPT systems.

**W3-2 [16:45]**

**Brief review of human dosimetry for exposure from wireless power transfer system at intermediate frequencies**

Akimasa Hirata<sup>1</sup>

<sup>1</sup>*Department of Electrical and Mechanical Engineering, Nagoya Institute of Technology, Nagoya, Japan, 4668555*

This presentation reviews the computational dosimetry for electromagnetic fields from wireless power transfer systems. Computational results are shown to discuss the compliance with international guidelines/standards.

**W4-1 [16:30]**

**Auricular vagus nerve stimulation: from basics to challenges**

Eugenijus Kaniusas<sup>1</sup>

<sup>1</sup>*Research group "Biomedical Sensing", Institute of Electrodynamics, Microwave and Circuit Engineering, Vienna, Austria, 1040*

Electrical stimulation of the auricular vagus nerve is an emerging electroceutical technology using digital doses of electrical pulses. The stimulation shows sustainable effects in treatment of systemic disorders of humans while restoring their homeostasis.

**W4-2 [16:50]**

**Modulation by field reversal — Cell volume, membrane potential, and 2 ns electrostimulation of excitable cells**

Esin B Sözer<sup>1</sup> & P. Thomas Vernier<sup>1</sup>

<sup>1</sup>*Frank Reidy Research Center for Bioelectronics, Old Dominion University, Norfolk, VA, USA, 23508*

Cell volume, intracellular ion concentrations, and membrane potential are interconnected. Changes in one will result in changes in the others. We report unexpected volume changes in cells exposed to 2 ns unipolar and bipolar electric pulses, and we propose that different permeabilizing structure sizes are responsible. We discuss whether these observations can help to explain the responses of

adrenal chromaffin cells to 2 ns electrical stimuli, where a transient rise in  $[Ca^{2+}]_i$  caused by a unipolar pulse can be eliminated by an immediately following pulse of the opposite polarity. This cancellation disappears for interphase intervals greater than 30 ns.

### W3-3 [17:00] - YOUNG SCIENTIST PAPER

#### Physics-based closed coupling factors for evaluating exposures to gradient magnetic fields

Ilaria Liorni<sup>1</sup>, Myles Capstick<sup>1</sup>, Sven Kuehn<sup>1</sup>, Esra Neufeld<sup>1</sup> & Niels Kuster<sup>1, 2</sup>

<sup>1</sup>IT'IS Foundation, Zuerich, Switzerland, 8004

<sup>2</sup>ETH Zuerich, Zuerich, Switzerland

Gradient magnetic fields (MFs) generated by wireless power transfer (WPT) systems can exceed the reference levels (RL) valid for homogeneous exposure. In RL-based testing, the MF gradient is neglected, and the exposure assessment based on basic restrictions (BR) can be overestimated by up to 40dB. In this study, we further improved the coupling factor for ICNIRP 1998 to translate the measured MF amplitudes and gradients into induced metrics for direct comparison with the BR. The coupling factor approximation has been simplified and is now supported by physics-based considerations and an extended numerical study. The same approach is currently being extended to coupling factors derived on the basis of all other published safety guidelines.

### W3-4 [17:15]

#### Exposure assessment of a Wireless Power Transfer system to recharge deep implants as leadless pacemakers

Valerio De Santis<sup>1</sup>, Tommaso Campi<sup>1</sup>, Silvano Cruciani<sup>1</sup> & Mauro Feliziani<sup>1</sup>

<sup>1</sup>Department of Industrial and Information Engineering and Economics, University of L'Aquila, Italy, Italy, 67100

This study deals with the battery recharge of a leadless pacemaker, which has been recently introduced in the market, by means of the wireless power transfer (WPT) technology based on the magnetic resonant coupling. The main difficulty is given by the depth of the leadless pacemaker implantation inside the human body. The electromagnetic problem mainly consists in the selection of the on-body excitation (primary coil current and frequency), which must adequately energize the leadless pacemaker without any

### W4-3 [17:10]

#### Investigational applications of Nano-Pulse Stimulation therapy in dermatology

Richard Nuccitelli<sup>1</sup> & Darrin Uecker<sup>1</sup>

<sup>1</sup>Biology, Pulse Biosciences, Hayward, USA, 94545

Nano-Pulse Stimulation and CellFX are for Investigational Use Only and Exclusively for Clinical Investigators. Pulse Biosciences has completed several clinical trials using a proprietary Nano-Pulse Stimulation™ CellFX™ System. The first clinical investigations are in cosmetic dermatology where several clinical trials have demonstrated safety and effectiveness in the treatment of both epidermal lesions such as seborrheic keratosis and dermal lesions such as sebaceous hyperplasia.

### W4-4 [17:30]

#### Lowering stimulation threshold by megahertz compression of nanosecond pulse bursts

Andrei Pakhomov<sup>1</sup>, Shu Xiao<sup>1, 2</sup>, Vitalij Novickij<sup>3</sup>, Iurii Semenov<sup>1</sup>, Maura Casciola<sup>1</sup>, Uma Mangalanathan<sup>1</sup> & Olga Pakhomova<sup>1</sup>

<sup>1</sup>Frank Reidy Research Center for Bioelectrics, Old Dominion University, Norfolk, VA, USA, 23508

<sup>2</sup>Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, VA, USA, 23508

<sup>3</sup>Vilnius Gediminas Technical University, Vilnius, Lithuania

A major limitation of nanosecond pulse stimulation (NPS) in research and clinical practice is the need for high pulse voltages, in order to exceed the electric field threshold for short pulse durations. This threshold increases as a power function with pulse shortening, up to tens of kV/cm for nanosecond-duration stimuli. We achieved

exceedance of the basic restrictions (BRs) specified by the electromagnetic field (EMF) safety standards.

### **W3-5 [17:30]**

#### **A 3 kW prototype for dynamic wireless power transfer: design and preliminary exposure assessment to emitted stray magnetic field**

Rosanna Pinto<sup>1</sup>, Vanni Lopresto<sup>1</sup>, Umberto Abronzini<sup>2</sup>, Damiano Capraro<sup>2</sup>, Mauro Di<sup>2</sup> & Antonino Genovese<sup>3</sup>

<sup>1</sup>*Division of Health Protection Technologies, ENEA, Rome, Italy*

<sup>2</sup>*University of Cassino and Southern Lazio, Cassino, Italy*

<sup>3</sup>*Production, Conversion and Use of Energy Division, ENEA, Rome, Italy*

Dynamic Wireless Power Transfer (DWPT) can represent a future solution for limited on-board energy resources of electric vehicles (EVs). In this paper a complete DWPT bench prototype is presented. A procedure for the exposure assessment to stray magnetic fields emitted by the prototype has been developed, to assess the compliance with the European reference levels for the general public. The compliance distance from the bench prototype is no less than 50 cm. The B-field plots during the movement of the pick-up coil have been measured. Future work will be devoted to the exposure assessment when the pick-up coil will be mounted on an EV. A numerical model of the actual exposure scenario will be realized for numerical dosimetry.

threshold reduction by more than an order of magnitude by delivering bursts of nanosecond pulses at ultra-high repetition rates (up to several MHz). We explored how the NPS threshold in mammalian cells and in nerve fibers depends on pulse duration, number of pulses, and their repetition rate or duty cycle.

### **W4-5 [17:50]**

#### **Long term control of cytosolic calcium oscillations in Mesenchymal Stem Cells using repeated electric pulses**

Shirmone Botha<sup>1</sup>, Borja Lopez<sup>2</sup>, Adeline Muscat<sup>1</sup>, Óscar Lucía<sup>2</sup>, Héctor Sarnago<sup>2</sup>, Alejandro Naval<sup>2</sup>, José-Miguel Burdio<sup>2</sup>, Tomás García-Sánchez<sup>1</sup>, Lluís M. Mir<sup>1</sup> & Franck Andre<sup>1</sup>

<sup>1</sup>*Vectorology and Anticancer Therapies, UMR 8203, CNRS, Gustave Roussy, Villejuif, France, 94805*

<sup>2</sup>*Department of Electronic Engineering and Communications, University of Zaragoza, Zaragoza, Spain, 50018*

In mesenchymal stem cells (MSCs), numerous studies describe the spontaneous oscillations of cytosolic calcium and their implication in MSCs differentiation. We demonstrate here that the application of high voltage micro second pulses can cancel natural calcium oscillations making it possible to insert an additional synthetic calcium oscillation pattern using repeated electric pulses over many hours. Pulsed electric fields can therefore be used as a tool for the long term control of cytosolic calcium oscillations in human adipose derived MSCs using a novel pulse generator as the one specifically developed. This tool could improve MSCs quality and differentiation.

### **W4-6 [18:10]**

#### **Molecular characterization of neuroblastoma cell line to single microsecond and nanosecond electric pulses: comparing low and high field amplitudes**

Claudia Consales<sup>1</sup>, Caterina Merla<sup>1</sup>, Barbara Benassi<sup>1</sup>, Adeline Muscat<sup>2</sup>, Tomás García-Sánchez<sup>2</sup>, Carmela Marino<sup>1</sup> & Lluís M. Mir<sup>2</sup>

<sup>1</sup>*Division of Health Protection Technologies, ENEA: Italian National Agency for new Technologies, Energy and Sustainable, ROME, Italy, 00123*

<sup>2</sup>*Laboratory for Vectorology in Anticancer Therapy UMR 8203, CNRS "Gustave Roussy", Villejuif, France, 94800*

Application of high voltage short electric pulses has attracted attention as a unique tool in life sciences, especially in cancer treatment, but the molecular mechanisms of their action on living organisms has not been yet fully elucidated. In this work the biological responses of the SH-SY5Y cells, a neuronal like cell line, exposed to high voltage short electric pulses, was investigated. In particular, four different types of voltage pulses lasting 100 microseconds and two different types of voltage pulses lasting 10 nanoseconds were applied to these cells. Cells responses were evaluated after a single pulse by analyzing cells redox metabolism modulation, apoptosis induction, and gene expression.

## Friday June 28, 2019

### Session: S13

Exposure assessment techniques II  
Friday June 28, 2019 • 09:00 - 10:30

Barthez

Chairs: Akimasa Hirata & Marthinus Van Wyk

### Session: S14

Emerging and Future Biomedical  
Applications

Friday June 28, 2019 • 09:00 - 10:30

Einstein

Chairs: Andrei Pakhomov & Theodoros Samaras

#### S13-1 [09:00]

##### RF EMF exposure sensing network in a smart-city context

Gunter Vermeeren<sup>1</sup>, Matthias Van Den Bossche<sup>1</sup>,  
Reza Aminzadeh<sup>1</sup>, Sam Aerts<sup>1</sup>, Philip Leroux<sup>2</sup>,  
Mats De Meyer<sup>3</sup>, Johan Bergs<sup>3</sup>, Astrid Philippron<sup>4</sup>,  
Luc Martens<sup>1</sup> & Wout Joseph<sup>1</sup>

<sup>1</sup>*imec - WAVES, Department of Information Technology at Ghent University, Ghent, Belgium, 9052*

<sup>2</sup>*imec - IDLab Ghent - Ghent University, Ghent, Belgium, 9052*

<sup>3</sup>*University of Antwerp - imec - IDLab - Department of Mathematics and Comput, Antwerp, Belgium, 2000*

<sup>4</sup>*Imec – City of Things, IoT & Connected Health Solutions, Antwerp, Belgium, 2000*

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (published)**  
**Presented by: Gunter Vermeeren**

Spatio-temporal radio-frequency (RF) electromagnetic field (EMF) exposure assessment is of interest for epidemiologists, governmental agencies dealing with environmental issues, and the general public. We designed low-cost EMF sensors and deployed an RF EMF exposure sensing network in the city of Antwerp (Belgium) consisting of eleven fixed EMF sensors and five mobile EMF sensors installed on the roof of postal vans. The EMF sensors were calibrated and validated in a lab environment and in the EMF sensor network in Antwerp using frequency-selective measurements. Such an EMF exposure network will enable long-term spatio-temporal exposure assessment on a local scale.

#### S13-2 [09:15]

##### Measurement scheme consideration for near-field reconstruction based on plane wave spectrum expansion using a phased array antenna at 28 GHz

Kun Li<sup>1</sup>, Kensuke Sasaki<sup>1</sup>, Soichi Watanabe<sup>1</sup>,  
Kanao Wake<sup>1</sup>, Junji Higashiyama<sup>2</sup> & Teruo Onishi<sup>2</sup>

#### S14-1 [09:00]

WITHDRAWN

#### S14-2 [09:15]

##### STUDENT PAPER

##### Bifurcation analysis of a stimulated Wendling's neural mass model

Marouan Arrais<sup>1</sup>, Fabrice Wendling<sup>1</sup> & Julien Modolo<sup>1</sup>

<sup>1</sup>*Laboratoire Traitement du Signal et de l'Image*

<sup>1</sup>National Institute of Information and Communications Technology, Tokyo, Japan

<sup>2</sup>NTT DoCoMo, Inc., Yokosuka, Japan

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**  
**Presented by: Kun Li**

For the compliance assessment of wireless devices operated at frequencies over 6 GHz, we have proposed a near-field reconstruction technique to estimate the power density to protect humans from excessive local temperature elevation due to millimeter wave exposure. The estimation accuracy and reproducibility of this method have been validated by standard gain horn and patch array antennas. In this study, the measurement conditions of employing the reconstruction technique for the assessment of power density were investigated using a phased patch array antenna at 28 GHz.

### S13-3 [09:30]

#### **Fast SAR estimation based on 3D field reconstructions and associated uncertainty quantifications**

Zicheng Liu<sup>1</sup> & Joe Wiart<sup>1</sup>

<sup>1</sup>Chaire C2M, LTCI, Télécom ParisTech, Université Paris-Saclay, Paris, France, 75013

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**  
**Presented by: Joe Wiart**

Fast SAR (specific absorption rate) estimation is achieved with the field reconstruction based on complex measurements on a single plane or phaseless measurements on two parallel planes. Expanding the measured fields into planar waves, the field reconstruction with complex measurements is performed through the retrieval of expansion coefficients. For phaseless measurements, estimating phase by the plane-to-plane algorithm, the field reconstruction follows the same approach with the complex measurements. Effects on SAR estimation by uncertain factors including the accuracy of measurements and liquid properties, position and coupling effects of probes will be considered and quantified by standard uncertainty and Sobol' indices.

(LTSI) - INSERM U1099, Rennes, France, 35700

**Keywords: Mechanistic/Theoretical, ELF/LF, Completed (unpublished)**  
**Presented by: Marouan Arrais**

**Objective:** Neurostimulation in epilepsy is a method of potential therapeutic value. First, we aim at simulating the local field potentials (LFPs) of an epileptogenic brain region under sinusoidal stimulation. Second, we aim at providing a detailed description of behaviors when stimulation parameters were varied.

**Methods:** We generated LFPs during stimulation using Wendling's neural mass model, simulating LFPs under normal and epileptic conditions. Bifurcations of the stimulated model were investigated.

**Results:** We identified sets of stimulation parameters that resulted in a switch epileptiform to normal background activity.

**Conclusion:** This model-guided approach leads to optimal stimulation parameters for seizure abortion.

### S14-3 [09:30]

#### **STUDENT PAPER**

#### **Effects of 50 Hz magnetic field on muscle hardness of the left forearm after muscle loading**

Tsukasa Kondo<sup>1</sup>, Hideyuki Okano<sup>2</sup>, Hiromi Ishiwatari<sup>3</sup> & Keiichi Watanuki<sup>1, 2, 4</sup>

<sup>1</sup>Graduate School of Science and Engineering, Saitama University, Saitama, Japan, 338-8570

<sup>2</sup>Advanced Institute of Innovative Technology, Saitama University, Saitama, Japan, 338-8570

<sup>3</sup>Soken Medical Co., Ltd., Tokyo, Japan, 171-0033

<sup>4</sup>Brain and Body System Science Institute, Saitama University, Saitama, Japan, 338-8570

**Keywords: Human, ELF/LF, Work in Progress**  
**Presented by: Tsukasa Kondo**

This study focuses on the acute influence of 50 Hz magnetic field ( $B_{\max}$  180 mT,  $B_{\text{rms}}$  127 mT for 15 min) on muscle hardness of the left forearm after muscle loading. In a randomised, double blind and crossover study design, magnetic field (MF) and sham control (CTL) exposures were carried out with 10 healthy volunteer subjects. The muscle loading in the left forearm was performed by the method of wrist curl training for 5 min using a dumbbell (3 kg). MF exposure significantly decreased the elevated muscle hardness of flexor carpi radialis compared with sham exposure. These results suggested that MF exposure could partially restore the elevated muscle hardness by muscle loading and thereby might ameliorate muscle fatigue and pain.

### S13-4 [09:45]

#### **Challenges to assess human exposure to 5G massive MIMO base stations**

Christian Bornkessel<sup>1</sup>, Thomas Kopacz<sup>2</sup>, Sascha Schiessl<sup>2</sup>, Dirk Heberling<sup>2, 3</sup> & Matthias Hein<sup>1</sup>

<sup>1</sup>*RF & Microwave Research Laboratory, TU Ilmenau, Ilmenau, Germany*

<sup>2</sup>*Institute of High Frequency Technology, RWTH Aachen University, Aachen, Germany*

<sup>3</sup>*Fraunhofer Institute for High Frequency Physics and Radar Techniques, Wachtberg, Germany*

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Christian Bornkessel**

5G radio base stations have to comply with safety limits with regard to human exposure in radio frequency electromagnetic fields (RF EMF) and thus are subject to national certification procedures. Due to different signal structures and the spatial beamforming, measurement- and calculation-based exposure assessment methods used for conventional mobile radio systems with static beams (2G, 3G, 4G) are no longer applicable for 5G massive MIMO base stations. This paper describes the most important exposure-relevant differences between conventional and 5G systems, formulates challenges for assessment, and sketches first concepts for correct exposure measurements.

### S13-5 [10:00]

#### **Measurement-based modeling of RF-EMF exposure in urban environments using artificial intelligence techniques**

Sam Aerts<sup>1</sup>, Yuanyuan Huang<sup>2</sup>, Luc Martens<sup>1</sup>, Wout Joseph<sup>1</sup> & Joe Wiart<sup>2</sup>

<sup>1</sup>*Department of Information Technology, Ghent University / imec, Ghent, Belgium*

<sup>2</sup>*Chaire C2M, Télécom ParisTech, Paris, France*

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Sam Aerts**

This study explores the use of artificial intelligence (AI) techniques to model the exposure to environmental radiofrequency (RF) electromagnetic fields (EMF) in an urban environment. For this, a spatial RF-EMF distribution was simulated in the 14th district of Paris, France, based on the existing base station infrastructure and a simple path loss model. Then, a number of sample measurements

### S14-4 [09:45]

#### **The extremely low-frequency electromagnetic field could induce apoptosis via accumulation of ROS and activation of L-type Calcium channels in breast cancer**

Alireza Madjid Ansari<sup>1</sup>, Mojdeh Barati<sup>2</sup>, Mohammad Amin Javidi<sup>1</sup> & Hossein Fahimi<sup>2</sup>

<sup>1</sup>*Integrative Oncology Department, Breast Cancer Research Center, Motamed Cancer Institute, ACECR, Tehran, Iran, 1517964311*

<sup>2</sup>*Department of Genetics, Faculty of Advanced Science and Technology, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran*

**Keywords: Mechanistic/Theoretical, ELF/LF, Completed (unpublished)**

**Presented by: Alireza Madjid Ansari**

ELF-EMF has been proposed as a potential adjuvant therapy in cancer treatment. Although there are many pieces of evidence about the apoptotic effects of ELF-EMF on cancer cells, the mechanism of action is still unknown. In this study, we evaluated the role of ROS and calcium channels during apoptosis induction by ELF-EMF. Our results showed that the inhibition of ROS as well as blocking the L-type calcium channels would lead to cease ELF-EMF induced apoptosis. Also, p38 and p21 genes expression were evaluated by using real-time PCR. In conclusion, we suggested that ELF-EMF might induce apoptosis in MC4L2 triple positive cell line by the accumulation of ROS, and benefiting from Ca<sup>2+</sup> L-type channels through calcium-ROS cell arrest pathway.

### S14-5 [10:00]

#### **NEUROMAN: Reference neuro-electrophysiology enabled computational human body models**

Bryn Lloyd<sup>1</sup>, Silvia Farcito<sup>1</sup>, Antonino Mario Cassara<sup>1</sup>, Esra Neufeld<sup>1</sup>, Beom Sun Chung<sup>3</sup>, Jin Seo Park<sup>4</sup>, Min Suk Chung<sup>3</sup> & Niels Kuster<sup>1, 2</sup>

<sup>1</sup>*IT'IS Foundation, Zürich, Switzerland, 8004*

<sup>2</sup>*ETH, Zurich, Switzerland*

<sup>3</sup>*Ajou University, Suwon, Korea*

<sup>4</sup>*Dongguk University, Gyeongju, Korea*

**Keywords: Dosimetry (computational), ELF/LF, Completed (unpublished)**

**Presented by: Bryn Lloyd**

To develop novel therapeutic electrostimulation devices, there is a need to build predictive computational tools, which allow to investigate mechanisms, and optimize treatments. While much progress has been made in recent years, computational electrophysiology still is lacking

were used to build and compare an artificial neural network (ANN) model and a conventional kriging interpolation model. The ability to use additional information (such as distance to base stations) in the NN model results in a promising approach – especially when measurement data are scarce – and more research is encouraged.

### S13-6 [10:15]

WITHDRAWN

anatomical models with detailed peripheral nerve connectivity. To this end, we are developing reference human anatomical models with unprecedented details in the peripheral nervous system, connectivity to organs and muscles, and functionalized with compartmental nerve models to investigate interactions with neuronal electrophysiology. The first of models, the Korean female Yoon-Sun V4, was recently released and the male Jeduk V4, will become available shortly

### S14-6 [10:15]

#### **Development of microfluidic tools to fabricate multicellular constructs and analyze their electromagnetic properties**

Marie Frénéa-Robin<sup>1</sup>, Jonathan Cottet<sup>2, 7</sup>, Julien Marchalot<sup>3</sup>, Charlotte Rivière<sup>4</sup>, Laure Franqueville<sup>2</sup>, Damien Voyer<sup>5</sup>, Clair Poignard<sup>6</sup>, Riccardo Scorretti<sup>2</sup> & Philippe Renaud<sup>7</sup>

<sup>1</sup>Univ Lyon, Université Claude Bernard Lyon 1, CNRS, Ampère, Villeurbanne, France, 69622

<sup>2</sup>Univ Lyon, Ecole Centrale de Lyon, CNRS, Ampère, Ecully, France, 69134

<sup>3</sup>Univ Lyon, Insa de Lyon, CNRS, Ampère, Villeurbanne, France, 69621

<sup>4</sup>Univ Lyon, Université Claude Bernard Lyon 1, CNRS, Institut Lumière Matière, Villeurbanne, France, 69622

<sup>5</sup>EIGSI, La Rochelle, France, 17041

<sup>6</sup>Inria Bordeaux, CNRS, Université de Bordeaux, Talence, France, 33405

<sup>7</sup>École Polytechnique Fédérale de Lausanne, EPFL-STI-IMT-LMIS4, Lausanne, Switzerland

**Keywords: Electroporation, IF, Work in Progress**  
**Presented by: Marie Frénéa-Robin**

Electroporation has many applications in the medical field such as electrochemotherapy, gene therapy and genetic screening. However, a thorough understanding of the effect of electrical pulses on tissues requires consideration of cell organization, interactions and microenvironment. Therefore, current studies aiming at studying electroporation in vitro are not only conducted on cell suspensions but also on 3D models closer from tissues, such as cell spheroids. We present the development of microfluidic tools dedicated to the reproducible construction of such 3D cellular assemblies. This bottom-up approach should also enable to analyze how electrical properties of multicellular constructs and of isolated cells relate to each other.

**Coffee Break**  
**Friday June 28, 2019 • 10:30 - 11:00**  
**Joffe 2-3**

**Session: P5**  
**Plenary 5 - Millimeter- and submillimeter-wave applications in biology and medicine:**  
**Potential and challenges**  
**Friday June 28, 2019 • 11:00 - 12:00**  
**Einstein**  
**Chairs: Maxim Zhadobov & Yasir Alfidhl**

**P5-1 [11:00]**

**Millimeter- and Submillimeter-Wave applications in biology: Potential and challenges**

Peter H. Siegel<sup>1</sup>

<sup>1</sup>*Caltech University, Pasadena, CA, USA, 91125*



#### **Biographical sketch**

Peter H. Siegel has held appointments as Faculty Associate in Electrical Engineering and Senior Scientist in Biology at the California Institute of Technology, and Senior Research Scientist at the NASA Jet Propulsion Laboratory, both in Pasadena, California. At JPL, he founded and led for 25 years, the Submillimeter Wave Advanced Technology (SWAT) team, a group of 20+ scientists and engineers developing THz technology for NASA's near and long term space missions. This included delivering key components for four major satellite missions and leading more than 75 smaller R&D programs for NASA and the US department of defence. At Caltech, Dr. Siegel has been involved in new biological and medical applications of THz, especially low power effects on neurons and most recently, millimeter-wave monitoring of blood chemistry. Among many other functions, he served as founding Editor-in-Chief of the IEEE Transactions on Terahertz Science and Technology (2010-2015) and founder, and now

the General Secretary, of the International Society of Infrared, Millimeter, and Terahertz Waves, the world's largest society devoted exclusively to THz science and technology. He is also an IEEE Fellow, and has served as an IEEE Distinguished lecturer, vice-chair and chair of IEEE MTTs Committee 4 – THz Technology, and an ad-hoc member of the MTTs AdCom for 5 years. Dr. Siegel has published more than 300 articles on THz components and technology and has given more than 250 invited talks on this subject throughout his career of 40 years in THz. His current appointments include: CEO of THz Global, a small R&D company specializing in RF bio applications; Senior Scientist Emeritus Biology and Electrical Engineering at Caltech; and Senior Research Scientist Emeritus and Principal Engineer at the NASA Jet Propulsion Laboratory.

Web Pages: <http://www.thz.caltech.edu>, <http://www.irmmw-thz.org>, <http://www.thz.ieee.org>,

Email: [phs@caltech.edu](mailto:phs@caltech.edu).

#### **Abstract**

The millimeter and submillimeter wave regimes, roughly spanning 30-3000 GHz, have moved to the forefront of recent expansion and innovative use of the RF spectrum. Traditional motivations for working at millimeter wavelengths have tended to focus mainly on commercial and defense-related wireless applications, such as communications, radar and to some extent, imaging. At higher THz frequencies, despite considerable commercial pressure, most of the emphasis is still on basic science, with a strong concentration in fundamental physics and chemistry, spectroscopy, and ground and space-based astrophysics, planetary atmospheres, and Earth science. As we move from the "Space Age" into the "Age of Biology" it is appropriate to take a closer look at what we can already do with millimeter and submillimeter-wave technology, and whether we might turn up any interesting new applications, or at least find some low hanging fruit which can be easily plucked, by simply refocusing some existing circuits and techniques. On the way, there are essential tweaks that have to be made to common devices and circuits in order to accommodate the constraints of water-based tissue. This talk will highlight some of the work the author has been involved with in applying high frequency circuits and techniques to problems in biology and medicine.

**Session: SA**  
**Awards Session**  
**Friday June 28, 2019 • 12:00 - 13:00**  
**Einstein**  
**Chairs: Azadeh Peyman & Anke Huss**

**SA-1 [12:00] -**

**Most Influential BEM Journal Papers for 2019 Award**

**SA-2 [12:20] -**

**Arthur Pilla Young Scientist Award**

**SA-3 [12:40] -**

**Students Awards**

**Closing Ceremony**  
**Friday June 28, 2019 • 13:00 - 13:30**  
**Einstein**

**Session: M5**  
**BEMS Board Meeting**  
**Friday June 28, 2019 • 15:00 - 18:00**  
**Joffre 4**

**Session: M6**  
**EBEA Council Meeting**  
**Friday June 28, 2019 • 15:00 - 18:00**  
**Joffre 5**

**Session: FA**  
**Student Flash Poster Session A**  
**Monday June 24, 2019 • 14:00 - 15:00**  
**Einstein**  
**Chairs: Niels Kuster & Christopher Portier**

**FA-1 [14:00]**  
**STUDENT PAPER**

**Development of microwave denervation catheter and its performance evaluation method**

Shohei Matsuhara<sup>1</sup>, Kazuyuki Saito<sup>1</sup>, Tomoyuki Tajima<sup>3</sup> & Nobuyoshi Takeshita<sup>2</sup>

<sup>1</sup>*Chiba University, Chiba, Japan*

<sup>2</sup>*National Cancer Center, Kashiwa, Japan*

<sup>3</sup>*The University of Tokyo Hospital, Tokyo, Japan*

**Keywords:** *Clinical (therapy), RF/Microwaves, Work in Progress*

**Presented by:** *Shohei Matsuhara*

In this study, a catheter which ablates extravascular nerve by the thermal effect of microwave is introduced. Moreover, heating characteristics of the catheter are evaluated by the numerical calculation and the experimental investigation. In addition, we consider a new method for evaluating the heating characteristics of microwave applicator. As a result, temperature distributions around the catheter became evident and the usefulness of a new method for evaluating the heating characteristics was suggested.

**FA-2 [14:03]**  
**STUDENT PAPER**

**Comparison of human body models for electromagnetic field exposure in a low-frequency band**

Jangyong Ahn<sup>1</sup>, Seon-eui Hong<sup>2</sup>, Haerim Kim<sup>1</sup>, Hyung-Do Choi<sup>2</sup> & Seungyoung Ahn<sup>1</sup>

<sup>1</sup>*Korea Advanced Institute of Science and Technology, Daejeon, Korea, 34141*

<sup>2</sup>*Electronics and Telecommunications Research Institute, Daejeon, Korea, 34129*

**Keywords:** *Dosimetry (computational), Static, Work in Progress*

**Presented by:** *Jangyong Ahn*

In the process of assessment of human exposure to electromagnetic fields, the evaluation against the basic restriction may be different depending on the human body models. In this paper, the evaluations of the internal quantities were performed using a WPT system operating at 140 kHz, and the calculated results were compared using several human body models. The results show that the electrostimulation effects dominate the thermal effects in the low-frequency band. In addition, the current density can be easily evaluated by using a simplified model with an equivalent conductivity value. On the other hand, the internal electric field differs depending on the physical shape so the anatomical model is used for the worst-case evaluation.

**FA-3 [14:06]**  
**STUDENT PAPER**

**Dosimetric analysis of hands exposure during handling of strong permanent magnets**

Mauro David<sup>1, 2</sup> & Gernot Schmid<sup>1, 2</sup>

<sup>1</sup>*UAS Technikum Wien, Vienna, Austria*

<sup>2</sup>*Seibersdorf Laboratories, Seibersdorf, Austria*

**Keywords:** *Dosimetry (computational), Static, Completed (unpublished)*

**Presented by:** *Mauro David*

Workers in a production line for synchronous motors reported tingling sensations in their hands when handling strong permanent magnets. To determine the dB/dt occurring along the hands a "measurement glove" containing 12 Hall sensors was realized and a new detailed anatomical hand model was developed. Temporal peak electric field strength ( $E_i$ ) induced inside the hand were estimated by numerical computations. The highest measured dB/dt along the palmar side of the hand was 51.17 T/s. The max  $E_i$  in soft tissue was

1.96 V/m, a factor of 1.8 higher than the applicable exposure limit value, but still lower than what is presently assumed the lowest stimulation threshold for peripheral nerves.

#### **FA-4 [14:09]**

##### **STUDENT PAPER**

#### **Mobile phone transmit power levels across signal strength for radiofrequency electromagnetic field exposure assessment**

Christopher Brzozek<sup>1, 2</sup>, Berihun Zeleke<sup>1, 2</sup>, Michael Abramson<sup>1, 2</sup>, Kurt Benke<sup>3, 4</sup> & Geza Benke<sup>1, 2</sup>

<sup>1</sup>*Centre for Population Health Research on Electromagnetic Energy (PRESEE), Monash University, Melbourne, Australia, 3004*

<sup>2</sup>*Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia, 3004*

<sup>3</sup>*University of Melbourne, Melbourne, Australia, 3052*

<sup>4</sup>*Department of Economic Development, Jobs, Transport and Resources (DEDJTR), AgriBio, Melbourne, Australia, 3083*

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Christopher Brzozek*

Radiofrequency electromagnetic field (RF-EMF) exposure assessment via mobile phone use is prone to measurement error. One aspect that is often overlooked is the different signal strengths over mobile phone transmission (Tx) power. The Qualipoc handheld android (SwissQual, Munich, DE), a tool for RF optimization, provides information on both signal strength and Tx power. We collected simultaneous measurements for Received Signal Strength Indicator, Reference Signal Received Power, Received Signal Code Power, Reference Signal Received Quality and Tx power on the 3G and 4G networks for analysis. In this analysis, the correlations with signal strength and variations in Tx power over different levels of signal strength are demonstrated.

#### **FA-5 [14:12]**

##### **STUDENT PAPER**

#### **nsPEFs exposure of liposomes to explore controlled drug delivery applications**

Laura Caramazza<sup>1, 2</sup>, Martina Nardoni<sup>3</sup>, Annalisa De Angelis<sup>1</sup>, Elena della Valle<sup>4</sup>, Agnese Denzi<sup>1</sup>, Patrizia Paolicelli<sup>3</sup>, Caterina Merla<sup>5</sup>, Micaela Liberti<sup>1</sup>, Francesca Apollonio<sup>1</sup> & Stefania Petralito<sup>3</sup>

<sup>1</sup>*ICEmB@DIET, Sapienza University of Rome, Rome, Italy, 00184*

<sup>2</sup>*Center for Life Nano Science@Sapienza, Istituto Italiano di Tecnologia, Rome, Italy, 00161*

<sup>3</sup>*Department of Drug Chemistry and Technology, Sapienza University of Rome, Rome, Italy, 00185*

<sup>4</sup>*Bioelectronic Vision Lab, Biomedical Engineering Department, University of Michigan, Ann Arbor, Michigan State, USA, 2800*

<sup>5</sup>*Division of Health Protection Technologies, ENEA, Rome, Italy, 00123*

**Keywords:** *Electroporation, Pulsed, Work in Progress*

**Presented by:** *Laura Caramazza*

The increasing interest towards biocompatible nanotechnologies in medicine, combined with electric fields stimulation, is leading to the development of electro-sensitive smart systems for drug delivery applications. Among the known electro-sensitive materials, phospholipids can be used to design nano-sized vesicles suitable for external electric actuation. To this regard, recently the use of pulsed electric fields to trigger release across phospholipid membranes has been numerically studied, for a deeper understanding of the phenomena at the molecular scale. Aim of this work is to give an experimental validation of the feasibility of controlling drug release from liposomes mediated by nanosecond pulsed electric fields.

#### **FA-6 [14:15]**

##### **STUDENT PAPER**

#### **Extremely low-frequency weak electromagnetic effects on fibrosarcoma (HT1080) and weak static magnetic field effects on Bacillus Subtilis**

Sahithi Kandala<sup>1</sup>, Mark Hernandez<sup>2</sup> & Frank Barnes<sup>1</sup>

<sup>1</sup>*Electrical, Computer and Energy Engineering, University of Colorado , Boulder, Colorado, USA, 80309*

<sup>2</sup>*Environmental and Civil Engineering, University of Colorado , Boulder, Colorado, USA, 80309*

**Keywords:** *In vitro, ELF/LF, Work in Progress*

**Presented by:** *Sahithi Kandala*

This paper explores the weak extremely-low-frequency electromagnetic effects on Fibrosarcoma cells and static magnetic field effects on Bacillus Subtiliscells. The effects of changes in frequency with constant electromagnetic field strength and changes in the magnetic field strength with constant frequency on growth rate and electron transport chain are discussed.

#### **FA-7 [14:18]**

##### **STUDENT PAPER**

#### **Inhibition of bacterial growth by application of small AC electric fields: a study to understand the interaction mechanisms**

Médéric Vindret<sup>1</sup>, Eric Chamberod<sup>2</sup>, Pascal Xavier<sup>1</sup>, Jean Martins<sup>3</sup> & Dominique Raully<sup>1</sup>

<sup>1</sup>*IMEP-LaHC, CNRS-UGA-GINP-USMB, GRENOBLE, France, 38000*

<sup>2</sup>*GEII, UGA, SAINT MARTIN D'HERES, France, 38400*

<sup>3</sup>*IGE, CNRS-UGA-GINP-IRD, GRENOBLE, France, 38000*

**Keywords:** *In vitro, IF, Work in Progress*

**Presented by:** *Médéric Vindret*

An innovative process was patented for the inhibition of bacterial growth in liquid media by the application of a low amplitude (< 1V/cm) AC electric field randomly varying into a wide band (10kHz-40MHz). An electrical modeling of the bacterial cell placed in a uniform AC field was carried out in parallel. To refine this modeling, an experimental study of the interaction of small amplitude electric fields with bacteria is described here to understand the origin of growth inhibition. This combines an electric field treatment of the suspension and simultaneous analysis by Electrical Impedance Spectroscopy (EIS). Particular attention has been paid to precisely control the applied electric field. Temperature of the liquid is also measured.

#### **FA-8 [14:21]**

##### **STUDENT PAPER**

#### **Acute exposure to cellphone radiofrequency signal: effect on young adolescent rat brain**

Kumari Singh<sup>1, 2</sup>, Rakesh Arya<sup>2, 3</sup>, Jayprakash Nirala<sup>1</sup>, Ranjan Nanda<sup>2</sup> & Paulraj Rajamani<sup>1</sup>

<sup>1</sup>*School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India, 110067*

<sup>2</sup>*Translation Health Group, International Center for Genetic Engineering and Biotechnology, New Delhi, India, 110067*

<sup>3</sup>*School of Life Sciences, Sambalpur University, Jyoti Vihar, Odisha, India, 768019*

**Keywords:** *In vivo, RF/Microwaves, Work in Progress*

**Presented by:** *Kumari Singh*

Now a days continuous use of cellphone for a long stretch of time are quite common specially among young adolescents, So present study was aimed at assesing effects of long term cellphone radiofrequency exposure on hippocampal redox enveronment and rate of neurogenesis in young adolescent rats.

#### **FA-9 [14:24]**

##### **STUDENT PAPER**

#### **Effects of 50 Hz magnetic field on cutaneous blood flow volume by cold, room temperature and warm water immersion test**

Nur Izyana Faradila Binti Azmi<sup>1</sup>, Hideyuki Okano<sup>2</sup>, Hiromi Ishiwatari<sup>3</sup> & Keiichi Watanuki<sup>1, 2, 4</sup>

<sup>1</sup>*Graduate School of Science and Engineering, Saitama University, Saitama, Japan, 338-8570*

<sup>2</sup>*Advanced Institute of Innovative Technology, Saitama University, Saitama, Japan, 338-8570*

<sup>3</sup>*Soken Medical Co., Ltd., Tokyo, Japan, 171-0033*

<sup>4</sup>*Brain and Body System Science Institute, Saitama University, Saitama, Japan, 338-8570*

**Keywords: Human, ELF/LF, Work in Progress**

**Presented by: Nur Izyana Faradila Binti Azmi**

This study focuses on the acute influence of 50 Hz magnetic field ( $B_{\max}$  180 mT,  $B_{\text{rms}}$  127 mT for 10 min) on recovery of cutaneous blood flow volume after cold (5°C), room temperature (25°C) and warm (42°C) water immersion for 1 min. In a randomised, double blind and crossover study design, magnetic field (MF) and sham control exposures were carried out with 10 healthy volunteers using a 2D laser speckle flowmetry. Except for the warm water immersion, the results showed that the blood flow recovery rate of part of the fingers was significantly faster and higher under MF exposure. These results suggested that MF could partially restore the reduced blood microcirculation in cold stress-induced ischemic conditions.

**FA-10 [14:27]**

**WITHDRAWN**

**FA-11 [14:30]**

**STUDENT PAPER**

**Experimental model simulation on electromagnetic wave therapy of apical periodontitis**

Hideo Taketani<sup>1</sup>, Masatake Akutagawa<sup>2</sup>, Hiromichi Yumoto<sup>3</sup>, Kouji Hirao<sup>3</sup>, Takahiro Emoto<sup>2</sup>, Hiroo Tarao<sup>4</sup>, Toshihiko Tominaga<sup>5</sup>, Toshitaka Ikehara<sup>6</sup> & Yohsuke Kinouchi<sup>2</sup>

<sup>1</sup>*Department of Electrical and Electronic Engineering, Graduate School of Advanced Technology and Science, Tokushima University, Tokushima, Japan, 770-8506*

<sup>2</sup>*Graduate School of Technology, Industrial and Social Sciences, Tokushima University, Tokushima, Japan, 770-8506*

<sup>3</sup>*Department of Periodontology and Endodontology, Tokushima University, Tokushima, Japan, 770-8504*

<sup>4</sup>*Department of Electrical and Computer Engineering, Kagawa National College of Technology, Takamatsu, Japan, 761-8058*

<sup>5</sup>*Tominaga Dental Clinic, Naruto, Japan, 771-0360*

<sup>6</sup>*Department of Human Welfare, Tokushima Bunri University, Tokushima, Japan, 770-8514*

**Keywords: Mechanistic/Theoretical, IF, Work in Progress**

**Presented by: Hideo Taketani**

The major current treatment of the apical periodontitis is cleaning of the root canal with chemicals. Recently EMAT (electro-magnetic apical treatment) have been proposed. EMAT is a treatment for sterilizing the root canal and regenerating the alveolar bone by applying voltage into the root canal. Although the experiment about the effect with EMAT is currently performed, the current density distribution in the experimental environment is still unknown. Thus, an experimental model was created and the current density distribution was obtained by simulation. As a result, it was thought that heat by applying voltage was transferred by convection from the electrode tips to the outside of the electrodes, and it was distributed to the whole PBS.

**FA-12 [14:33]**

**WITHDRAWN**

**Session: PA**  
**Poster Session A**  
**Monday June 24, 2019 • 15:00 - 16:30**  
**Joffre 2-3**

**PA-1 [15:00]**

**Radiofrequency electromagnetic fields hypersensitivity or idiopathic environmental intolerance: an updated systematic review of provocation studies, perception and media influence**

Víctor Cristóbal<sup>1</sup>, Jesus Gonzalez-Rubio<sup>1</sup> & Alberto Nájera<sup>1</sup>

<sup>1</sup>*Medical Sciences, University of Castilla-La Mancha, Albacete, Spain, 05008*

**Keywords: Behavioural, RF/Microwaves, Work in Progress**

**Presented by: Alberto Nájera**

An updated systematic review of provocation studies, perception and media influence about radiofrequency electromagnetic fields hypersensitivity or idiopathic environmental intolerance during the years 2011-18

**PA-3 [15:00]**

**WITHDRAWN**

**PA-5 [15:00]**

**WITHDRAWN**

**PA-7 [15:00]**

**Spontaneous motility of yeast cells as a tool for biological electromagnetic effect assessment**

Michal Teplan<sup>1</sup>, Ivan Bajla<sup>1</sup> & Martin Bereta<sup>1</sup>

<sup>1</sup>*Institute of Measurement Science SAS, Bratislava, Slovakia (Slovak Republic), 84104*

**Keywords: Clinical (diagnostics), All Frequencies, Work in Progress**

**Presented by: Michal Teplan**

Inverted light microscopy connected to a digital camera provides a monitoring tool for quantitative characterization of motility and morphology of yeast cells in liquid solution. The video frames are segmented by an automatic image processing. Algorithms for image pre-processing, including segmentation followed by tracking procedures of the segmented image objects are investigated. Measure of cell spatial fluctuation have been derived from frequency spectrum. Obtained frequency spectra reflect periodicity in cells' vibrational movement. Derived cell motility measures reflect viability and metabolic activity of cells.

**PA-9 [15:00]**

**STUDENT PAPER**

**Development of microwave denervation catheter and its performance evaluation method**

Shohei Matsuhara<sup>1</sup>, Kazuyuki Saito<sup>1</sup>, Tomoyuki Tajima<sup>3</sup> & Nobuyoshi Takeshita<sup>2</sup>

<sup>1</sup>*Chiba University, Chiba, Japan*

<sup>2</sup>*National Cancer Center, Kashiwa, Japan*

<sup>3</sup>*The University of Tokyo Hospital, Tokyo, Japan*

**Keywords: Clinical (therapy), RF/Microwaves, Work in Progress**

**Presented by: Shohei Matsuhara**

In this study, a catheter which ablates extravascular nerve by the thermal effect of microwave is introduced. Moreover, heating characteristics of the catheter are evaluated by the numerical calculation and the experimental investigation. In addition, we consider a new method for evaluating the heating characteristics of microwave applicator. As a result, temperature distributions around the catheter became evident and the usefulness of a new method for evaluating the heating characteristics was suggested.

**PA-11 [15:00]**  
**STUDENT PAPER**

**Comparison of human body models for electromagnetic field exposure in a low-frequency band**

Jangyong Ahn<sup>1</sup>, Seon-eui Hong<sup>2</sup>, Haerim Kim<sup>1</sup>, Hyung-Do Choi<sup>2</sup> & Seungyoung Ahn<sup>1</sup>

<sup>1</sup>*Korea Advanced Institute of Science and Technology, Daejeon, Korea, 34141*

<sup>2</sup>*Electronics and Telecommunications Research Institute, Daejeon, Korea, 34129*

**Keywords:** *Dosimetry (computational), Static, Work in Progress*

**Presented by:** *Jangyong Ahn*

In the process of assessment of human exposure to electromagnetic fields, the evaluation against the basic restriction may be different depending on the human body models. In this paper, the evaluations of the internal quantities were performed using a WPT system operating at 140 kHz, and the calculated results were compared using several human body models. The results show that the electrostimulation effects dominate the thermal effects in the low-frequency band. In addition, the current density can be easily evaluated by using a simplified model with an equivalent conductivity value. On the other hand, the internal electric field differs depending on the physical shape so the anatomical model is used for the worst-case evaluation.

**PA-13 [15:00]**

**Innovative stochastic modeling of residential exposure due to a WiFi source placed in uncertain position**

Emma Chiaramello<sup>1</sup>, David Plets<sup>2</sup>, Serena Fiocchi<sup>1</sup>, Marta Bonato<sup>1, 4</sup>, Gabriella Tognola<sup>1</sup>, Marta Parazzini<sup>1</sup>, Laurent Le Brusquet<sup>3</sup>, Luc Martens<sup>2</sup>, Wout Joseph<sup>2</sup> & Paolo Ravazzani<sup>1</sup>

<sup>1</sup>*Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni, Consiglio Nazionale delle Ricerche, Milano, Italy, 20133*

<sup>2</sup>*INTEC-WAVES imec, Ghent University/IMEC, Ghent, Belgium, 9052*

<sup>3</sup>*Laboratoire des Signaux et Systèmes, CNRS, Univ Paris-Sud, Université Paris-Saclay, Paris, France, 8506*

<sup>4</sup>*Dipartimento di Elettronica, Informazione e Bioingegneria DEIB, Politecnico di Milano, Milano, Italy, 20133*

**Keywords:** *Dosimetry (computational), RF/Microwaves, Completed (unpublished)*

**Presented by:** *Emma Chiaramello*

This study focused on the exposure evaluation of the 2D spatial distribution of the E-field in a one-floor apartment when a WiFi source is placed in uncertain position. An innovative approach that combines a Principal Component Analysis and Kriging model in order to build space-dependent surrogate models was applied and validated. Results showed the feasibility of the approach.

**PA-15 [15:00]**

**Numerical evaluation of the influence of RF-exposure conditions on heating induced by interventional catheters**

Micol Colella<sup>1</sup>, Elena Lucano<sup>1, 2</sup>, Francesca Apollonio<sup>1</sup>, Qi Zeng<sup>3</sup>, Jingshen Liu<sup>3</sup>, Tom Lloyd<sup>4</sup>, Steve Wedan<sup>4</sup>, Ji Chen<sup>3</sup>, Wolfgang Kainz<sup>5</sup>, Micaela Liberti<sup>1</sup> & Leonardo M. Angelone<sup>5</sup>

<sup>1</sup>*Department of Information Engineering, Electronics and Telecommunications (DIET), University of Rome "La Sapienza", Rome, Italy, 00184*

<sup>2</sup>*InsilicoTrials Technology, Milan, Italy, 20121*

<sup>3</sup>*Electrical and Computer Engineering, University of Houston, Houston, TX, USA, 77004*

<sup>4</sup>*Imricor Medical Systems Inc., Burnsville, MN, USA, 55337*

<sup>5</sup>*Office of Science and Engineering Laboratories, Center for Devices and Radiological Health, US FDA, Silver Spring, MD, USA, 20993*

**Keywords:** *Dosimetry (computational), RF/Microwaves, Completed (unpublished)*

**Presented by:** *Micol Colella*

This study aims to numerically investigate the temperature increase that occurs at the tip of a "dual wire"

partially-implanted lead due to the RF-induced heating. We explored 32 different exposure conditions for the human body model Duke of the Virtual Population. The temperature increase is computed using the transfer function experimentally determined for the specific lead.

#### **PA-17 [15:00]**

##### **STUDENT PAPER**

##### **Dosimetric analysis of hands exposure during handling of strong permanent magnets**

Mauro David<sup>1,2</sup> & Gernot Schmid<sup>1,2</sup>

<sup>1</sup>*UAS Technikum Wien, Vienna, Austria*

<sup>2</sup>*Seibersdorf Laboratories, Seibersdorf, Austria*

**Keywords:** *Dosimetry (computational), Static, Completed (unpublished)*

**Presented by:** *Mauro David*

Workers in a production line for synchronous motors reported tingling sensations in their hands when handling strong permanent magnets. To determine the dB/dt occurring along the hands a “measurement glove” containing 12 Hall sensors was realized and a new detailed anatomical hand model was developed. Temporal peak electric field strength ( $E_i$ ) induced inside the hand were estimated by numerical computations. The highest measured dB/dt along the palmar side of the hand was 51.17 T/s. The max  $E_i$  in soft tissue was 1.96 V/m, a factor of 1.8 higher than the applicable exposure limit value, but still lower than what is presently assumed the lowest stimulation threshold for peripheral nerves.

#### **PA-19 [15:00]**

##### **New formulations for numerical dosimetry at intermediate frequencies**

Giacomo di Benedetto<sup>1</sup>, Riccardo Scorretti<sup>1</sup>, Christophe Geuzaine<sup>2</sup>, Kassem Jomaa<sup>3</sup>, Méline Bouldi<sup>4</sup> & Fabien Ndagijimana<sup>3</sup>

<sup>1</sup>*Lab. Ampère - UMR 5005 CNRS, Ecole Centrale de Lyon, Ecully, France, 69134*

<sup>2</sup>*Department of Electrical Engineering and Computer Science, University of Liège, Liège, Belgium, 4000*

<sup>3</sup>*IMEP-LaHC Laboratory, Université de Grenoble Alpes, Grenoble, France*

<sup>4</sup>*INRS, Nancy, France*

**Keywords:** *Dosimetry (computational), RF/Microwaves, Work in Progress*

**Presented by:** *Riccardo Scorretti*

Numerical dosimetry is an essential step to assess the safety of workers exposed to electromagnetic fields. In the case of intermediate frequencies exposure happens in close field and classical numerical formulations for numerical dosimetry require the electric field as source. In these conditions, experimental measurement of the electric field is quite a difficult task, whereas the magnetic field is much simpler to measure. In this work new formulations which make use of the magnetic field as source term are developed.

#### **PA-21 [15:00]**

##### **Magnetic targeting on heart tissues: modelling of magnetic forces**

Serena Focchi<sup>1</sup>, Marta Bonato<sup>1,2</sup>, Emma Chiaramello<sup>1</sup>, Gabriella Tognola<sup>1</sup>, Marta Parazzini<sup>1</sup> & Paolo Ravazzani<sup>1</sup>

<sup>1</sup>*Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni IEIT, CNR Consiglio Nazionale delle Ricerche, Milan, Italy, 20133*

<sup>2</sup>*Dipartimento di Elettronica Informazione e Bioingegneria DEIB, Politecnico di Milano, Milan, Italy, 20133*

**Keywords:** *Dosimetry (computational), Static, Work in Progress*

**Presented by:** *Marta Bonato*

The successful use of nanoparticles in therapeutic applications has recently prompted scientists to look for effective strategies to focus them in specific organs. Among these methods, magnetic targeting consists in the use of magnets or coils capable of producing high-gradient magnetic fields (and therefore magnetic forces) on the magnetic nanoparticles, thus increasing their concentration in the target. Although some

experimental studies have shown the efficacy of this technique, there are still few studies able to quantify the experimental results. In this study, the behavior of various magnetic targeting systems, optimized on the anatomy of different anatomical models, was evaluated by means of computational electromagnetic techniques.

#### **PA-23 [15:00]**

##### **Which deep brain regions are most activated in a group of subjects by non-invasive stimulation techniques?**

Jose Gomez-Tames<sup>1</sup>, Akihiro Asai<sup>1</sup>, Atsushi Hamasaka<sup>1</sup>, Ilkka Laakso<sup>2</sup>, Mai Lu<sup>3</sup>, Shoogo Ueno<sup>4</sup> & Akimasa Hirata<sup>1</sup>

<sup>1</sup>*Department of Electrical and Mechanical Engineering, Nagoya Institute of Technology, Nagoya, Japan*

<sup>2</sup>*Department of Electrical Engineering and Automation, Aalto University, Espoo, Finland*

<sup>3</sup>*Key Lab. of Opt-Electronic Technology and Intelligent Control of Ministry of Education, Lanzhou Jiaotong University, Gansu Sheng, China*

<sup>4</sup>*Department of Biomedical Engineering, University of Tokyo, Tokyo, Japan*

**Keywords:** *Dosimetry (computational), ELF/LF, Completed (published)*

**Presented by:** *Jose Gomez-Tames*

Neuromodulation dosage delivered by non-invasive stimulation techniques has been determined in a group of subjects at deep brain regions. We used high-resolution computational models with registration techniques for post-processing analysis at group-level using an average template of deep brain regions for the first time. Despite the inter-individual variations, a systematic tendency of the electric field hotspot emerges in specific deep brain locations

#### **PA-25 [15:00]**

##### **Exposure assessment of induced electric fields in the human body for different realistic occupational scenarios in 50Hz high voltage plants**

Rene Hirtl<sup>1</sup>, Gernot Schmid<sup>1</sup>, Katrin Friedl<sup>2</sup> & Klemens Reich<sup>3</sup>

<sup>1</sup>*EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, 2444*

<sup>2</sup>*Graz University of Technology, Graz, Austria, 8010*

<sup>3</sup>*Austrian Power Grid AG, Vienna, Austria, 1220*

**Keywords:** *Dosimetry (computational), ELF/LF, Completed (unpublished)*

**Presented by:** *Rene Hirtl*

Electric fields in areas of 50Hz high voltage plants are typically found to be close to the reference values or action levels, or may even locally exceed them. In such electrically dominant exposure situations, demonstration of compliance with exposure limits is often only possible based on the induced electric field strengths inside the body and comparison with the exposure limit values. Numerical simulations of several exposure situations in the area of such high voltage plants were therefore conducted and analyzed with realistic human body models. Evaluation of induced electric field strengths have shown compliance with the exposure limit values in all investigated realistic exposure scenarios, even when action levels were exceeded.

#### **PA-27 [15:00]**

##### **Analyzing the impact of grating lobes of 5G massive MIMO antennas on the vertical compliance distance**

Thomas Kopacz<sup>1</sup>, Sascha Schiessl<sup>1</sup> & Dirk Heberling<sup>1, 2</sup>

<sup>1</sup>*Institute of High Frequency Technology, RWTH Aachen University, Aachen, Germany*

<sup>2</sup>*Fraunhofer Institute for High Frequency Physics and Radar Techniques, Wachtberg, Germany*

**Keywords:** *Dosimetry (computational), RF/Microwaves, Work in Progress*

**Presented by:** *Thomas Kopacz*

An important factor for the rollout of 5G networks are high-gain massive MIMO antennas which allow for

beamforming and steering which, in turn, increases spectral efficiency. To reduce complexity, the antenna consists of subarrays causing grating lobes in case of beam steering. In this paper, we investigate the impact of the vertical scanning range on the vertical compliance distance and compare the results to an antenna without grating lobes. The main lobe dominates the vertical compliance distance as long as a part of it is below the horizon. In case of a downtilt of the main beam, the grating lobes even reduce the vertical compliance distance. In case of an uptilt, they strongly increase the vertical compliance distance.

#### **PA-29 [15:00]**

##### **Occupational compliance distances for multiband base station antennas**

Gunter Vermeeren<sup>1</sup>, Wout Joseph<sup>1</sup> & Luc Martens<sup>1</sup>

<sup>1</sup>*imec - WAVES, Department of Information Technology at Ghent University, Ghent, Belgium, 9052*

**Keywords: Dosimetry (computational), RF/Microwaves, Completed (published)**

**Presented by: Gunter Vermeeren**

We designed a generic multi-band base station antenna model (BSA) based on a commercially available dual-band BSA. The model, consisting of 64 crossed-polarized dipole elements, showed good agreement with the commercial BSA in terms of maximum gain (maximum deviation of 1.3 dB for the frequency bands of 700MHz, 800MHz, 900MHz, 1800MHz, 2100MHz, and 2600MHz). Using the generic BSA model, we assessed the compliance distance by evaluating the exposure according to CENELEC EN50383 and comparing the exposure with ICNIRP reference levels for occupational exposure. As expected, the compliance distance is the smallest in front of the BSA (e.g., at 700MHz the compliance distance is 1.5m for a power of 50dBm) and the largest at the back of the BSA.

#### **PA-31 [15:00]**

##### **Development of detailed surface-based numerical hand models for computational dosimetry**

Richard Überbacher<sup>1</sup>, Gerhard Netzker<sup>2</sup>, Rene Hirtl<sup>1</sup>, Klaus Schiessl<sup>2</sup> & Gernot Schmid<sup>1</sup>

<sup>1</sup>*EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, A-2444*

<sup>2</sup>*Austrian Workers' Compensation Board (AUVA), Vienna, Austria, A-1200*

**Keywords: Dosimetry (computational), All Frequencies, Work in Progress**

**Presented by: Gernot Schmid**

Three novel surface-based highly detailed anatomical models of the hand and lower arm region, in different frequently observed hand postures have been developed based on MRI images. In total 15 different tissues types were distinguished during segmentation, including a multilayer skin model separating subcutaneous adipose tissue, dermis, epidermis and stratum corneum. These models are intended to enable a detailed analysis of the spatial distribution of induced electric field strengths inside the hand, particularly in case of highly localized magnetic field exposure of the hands and lower arms, as it may be frequently observed in occupational settings. However, the developed hand/lower arm models may also be used in biomedical applications.

#### **PA-33 [15:00]**

**WITHDRAWN**

#### **PA-35 [15:00]**

**STUDENT PAPER**

##### **Mobile phone transmit power levels across signal strength for radiofrequency electromagnetic field exposure assessment**

Christopher Brzozek<sup>1, 2</sup>, Berihun Zeleke<sup>1, 2</sup>, Michael Abramson<sup>1, 2</sup>, Kurt Benke<sup>3, 4</sup> & Geza Benke<sup>1, 2</sup>

<sup>1</sup>*Centre for Population Health Research on Electromagnetic Energy (PRESEE), Monash University, Melbourne, Australia, 3004*

<sup>2</sup>*Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia, 3004*

<sup>3</sup>*University of Melbourne, Melbourne, Australia, 3052*

<sup>4</sup>Department of Economic Development, Jobs, Transport and Resources (DEDJTR), AgriBio, Melbourne, Australia, 3083

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Christopher Brzozek*

Radiofrequency electromagnetic field (RF-EMF) exposure assessment via mobile phone use is prone to measurement error. One aspect that is often overlooked is the different signal strengths over mobile phone transmission (Tx) power. The Qualipoc handheld android (SwissQual, Munich, DE), a tool for RF optimization, provides information on both signal strength and Tx power. We collected simultaneous measurements for Received Signal Strength Indicator, Reference Signal Received Power, Received Signal Code Power, Reference Signal Received Quality and Tx power on the 3G and 4G networks for analysis. In this analysis, the correlations with signal strength and variations in Tx power over different levels of signal strength are demonstrated.

#### **PA-37 [15:00]**

##### **Epigenetic changes following exposure to radiofrequency fields**

Ibtissam Echchgadda<sup>1</sup>, Xomalin Peralta<sup>2</sup>, Cesar Cerna<sup>3</sup> & Jody Cantu<sup>3</sup>

<sup>1</sup>*Air Force Research Laboratory, Radio Frequency Bioeffects Branch, Fort Sam Houston, Texas, USA, 78234*

<sup>2</sup>*National Academy of Sciences NRC Research Associateship, Fort Sam Houston, Texas, USA, 78234*

<sup>3</sup>*General Dynamics Information Technology, Fort Sam Houston, Texas, USA, 78234*

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Ibtissam Echchgadda*

It remains unclear if exposure to RF fields induce epigenetic modifications in cells that would influence gene expression. In this study, we examined how exposure to RF fields at various E fields and durations can affect DNA methylation. We exposed primary human keratinocytes to 900 MHz RF and measured global changes in DNA methylation using methylation sensitive restriction digestion and ELISA. Results show differential DNA methylation patterns in RF exposed cells compared to non-exposed control cells under non-thermal and non-toxic exposure conditions. This suggests that RF exposure changes DNA methylation patterns, which could potentially have downstream effects on gene expression.

#### **PA-39 [15:00]**

##### **A real-world quality assessment study in six ExpoM-RF measurement devices**

Marloes Eeftens<sup>1, 2</sup>, Stefan Dongus<sup>1, 2</sup>, Alexandra Bürgler<sup>1, 2</sup> & Martin Röösli<sup>1, 2</sup>

<sup>1</sup>*Environmental Exposures and Health Unit, Swiss Tropical and Public Health Institute, Basel, Switzerland, 4051*

<sup>2</sup>*University of Basel, Basel, Switzerland, 4051*

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Completed (unpublished)*

**Presented by:** *Marloes Eeftens*

Exposimeters for mobile measurements of radiofrequency electromagnetic fields are usually calibrated in an anechoic chamber using defined signals and standardized orientations. However, it is not clear how measurements from different devices compare in real-world environments. We thus tested the comparability of six ExpoM-RF exposimeters before and after calibration by varying their position and orientation while repeatedly measuring 15 microenvironments on six different days. We found that systematic differences introduced by device ID, calibration, day of the week, orientation and position are relatively small compared to exposure differences between microenvironments. This supports the validity of studies relying on ExpoM-RF devices.

#### **PA-41 [15:00]**

##### **Experimental estimation on temperature rise in human tissue due to implanted metal plates using novel translucent semi-solid phantom**

Takashi Hikage<sup>1</sup>, Suzune Ito<sup>1</sup>, Toshio Nojima<sup>1</sup>, Tomoaki Nagaoka<sup>2</sup> & Soichi Watanabe<sup>2</sup>

<sup>1</sup>Graduate School of Information Science and Technology, Hokkaido University, Sapporo, Japan, 0600814

<sup>2</sup>National Institute of Information and Communications Technology, Tokyo, Japan

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Takashi Hikage*

This paper introduced experimental evaluations for temperature rise in human tissue with two metal implants aligned in parallel. To investigate the impact of the two metal implants, temperature increase measurements using newly developed translucent semi-solid phantoms were conducted. In the measured distributions, temperature rise due to the metallic plates was clearly observed in the gap of two metal plates region.

#### **PA-43 [15:00]**

##### **Assessment of electromagnetic field exposure levels from wireless charging system for drone**

Seon-eui Hong<sup>1</sup> & Hyung-Do Choi<sup>1</sup>

<sup>1</sup>Radio Environment & Monitoring Research Group, ETRI, Daejeon, Korea, 34129

**Keywords:** *Dosimetry (measurements), ELF/LF, Work in Progress*

**Presented by:** *Seon-eui Hong*

Wireless charging technologies are widely applied mobile bodies such as drones, robots, and electric vehicles. In this paper, we investigate electromagnetic field (EM) levels from wireless charging system for drone. The operating system and transmitting power are 140 kHz and 200 W, respectively. It was shown that electric field and magnetic field strengths around the wireless charging exceed the reference level of ICNIRP's guideline.

#### **PA-45 [15:00]**

##### **Analysis of electromagnetic fields exposure measurement around substation and sensitive area**

Jeongill Hwang<sup>1</sup>, Sang-su Noh<sup>1</sup>, Kyungku Nah<sup>1</sup>, Chang-nam Jin<sup>1</sup>, Seungwoo Lee<sup>2</sup> & Ho Sung An<sup>2</sup>

<sup>1</sup>Transmission and Substation Construction Dept., KEPCO, Naju, Korea, 58217

<sup>2</sup>Power Transmission Laboratory, KEPRI, Daejeon, Korea, 34056

**Keywords:** *Dosimetry (measurements), ELF/LF, Work in Progress*

**Presented by:** *Kyungku Nah*

In this study, about 150 substations were selected to be measured by classifying Korean Substations, and the amount of MF exposure was measured and analyzed for the substation area and sensitive facilities near the substation. The amount of EMF variation with distance was analyzed. Further, for long term exposure analysis, 24 hours of long-term measurement was performed for substations with relatively large electromagnetic fields exposure. The analysis showed that the average exposure amount was between 0.055~2.282uT around the substation, and the maximum value was 0.25 to 1.7uT with 24 hours of measurement for particular substations. We found these values are very small compared to the reference value.

#### **PA-47 [15:00]**

##### **Assessment of actual maximum RF EMF exposure from radio base stations with massive MIMO antennas**

Paramananda Joshi<sup>1</sup>, Davide Colombi<sup>1</sup> & Christer Tornevik<sup>1</sup>

<sup>1</sup>Ericsson Research, Ericsson AB, Stockholm, Sweden

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Completed (published)*

**Presented by:** *Paramananda Joshi*

The actual output power levels of radio base stations (RBSs) with massive MIMO (mMIMO) antennas have been assessed via a network-based study conducted in an operating mobile network. Knowledge of spatial distribution of output power, in addition to the total output power, is essential for accurate evaluations of RF EMF exposure from mMIMO antennas. With the method used in this study, which was found to be consistent with a mathematical model to evaluate EMF exposure from mMIMO antennas, actual output power (95<sup>th</sup>

percentile) per beam under high traffic conditions and considering a Time Division Duplexing (TDD) downlink duty cycle of about 75% was found to be 16% of the maximum possible output power from the RBSs.

#### **PA-49 [15:00]**

##### **Measurement for the extremely low frequency magnetic field in the shared electric vehicles**

Jun Lin<sup>1</sup> & Tongning Wu<sup>1</sup>

<sup>1</sup>*China Academy of Information and Telecommunications Technology, Beijing, China, 100191*

**Keywords:** *Dosimetry (measurements), ELF/LF, Completed (published)*

**Presented by:** *Tongning Wu*

Shared EVs emerged and were used by more and more people. Shared EVs may be frequently used and they were undergone more frequent maintenance compared to the private owned EVs. The mounting and dismounting during the regular maintenance could potentially modify the layout of the electric system as well as the coverage in the vehicle. As result, the magnetic field distribution in the vehicle could alter. In the study, we measured the magnetic flux density (B) for 3 popular shared EVs in Beijing. In total, four driving sessions of the EVs were involved in the measurements,. The results were recorded and compared for three times of maintenance.

#### **PA-51 [15:00]**

##### **Impact of 60 Hz magnetic and electric fields at high intensity on automated external defibrillator (AED)**

Duc-Hai Nguyen<sup>1</sup>, Alain Turgeon<sup>1</sup> & Genevieve Ostiguy<sup>2</sup>

<sup>1</sup>*Hydro-Quebec Research Institute, Varennes, Quebec, Canada, J3X 1S1*

<sup>2</sup>*Hydro-Quebec Health and Safety Direction, Montreal, Quebec, Canada*

**Keywords:** *Dosimetry (measurements), ELF/LF, Completed (unpublished)*

**Presented by:** *Duc-Hai Nguyen*

The automated external defibrillator (AED) is more and more required in work place. The device is exposed to the environment of power utilities installations, such as substation areas and power generation floors to verify if the device can operate securely and reliably in a high intensity of magnetic or electric field.

#### **PA-53 [15:00]**

##### **Smartphone measurements as a basis for a crowdsourcing-based monitoring of EMF exposure**

Sascha Schiessl<sup>1</sup>, Thomas Kopacz<sup>1</sup> & Dirk Heberling<sup>1, 2</sup>

<sup>1</sup>*Institute of High Frequency Technology, RWTH Aachen University, Aachen, Germany*

<sup>2</sup>*Fraunhofer Institute for High Frequency Physics and Radar Techniques, Wachtberg, Germany*

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Sascha Schiessl*

The continuous monitoring of exposure to radio-frequency electromagnetic fields is a great challenge when considering the classical assessment methods using professional measuring equipment, which are costly and can only be carried out on a limited scale. A possible way to solve this problem could be a crowdsourcing-based approach, which relies on the use of common smartphones and their built-in measurement capability. In this paper, we present the essential parameters that a mobile device captures and discuss how they can serve as a measure of EMF exposure. In addition, the results of some tests to verify the applicability are provided. Furthermore, we will discuss some challenges to make use of smartphone measurements.

#### **PA-55 [15:00]**

##### **An innovative experimental protocol for the study of electromagnetic hypersensitivity: overview of technical aspects**

Benjamin Vatovez<sup>1</sup>, Ahmed Guettafi<sup>1</sup>, Luc Verschaeve<sup>2</sup>, Maryse Ledent<sup>2</sup>, Christophe Geuzaine<sup>3</sup>, Veronique Beauvois<sup>3</sup>, Maël Dieudonné<sup>4</sup>, Jimmy Bordarie<sup>5</sup>, Nicolas Prignot<sup>6</sup> & Willy Pirard<sup>1</sup>

<sup>1</sup>*Electromagnetic Fields Department, Scientific Institute of Public Service (ISSeP), Liège, Belgium, 4000*

<sup>2</sup>*Risk assessment, Scientific Institute of Public Health (WIV-ISP), Brussels, Belgium, 1050*

<sup>3</sup>*Applied and Computational Electromagnetics (ACE), University of Liège (ULiège), Liège, Belgium, 4000*

<sup>4</sup>*Centre Max Weber (CMW), Lyon, France, 69007*

<sup>5</sup>*University of Paris 3 (Sorbonne Nouvelle), Paris, France, 75231*

<sup>6</sup>*Constructivist Studies Group (GECO), University of Brussels (ULB), Brussels, Belgium, 1050*

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Benjamin Vatovez**

The ExpoComm project aims at developing an innovative protocol for the experimental study of electromagnetic hypersensitivity (EHS). Its first part consisted in a collaborative work between EHS volunteers and scientists to define crucial aspects of the protocol, notably exposure parameters. The protocol is now fully developed, and its implementation has begun. It includes a specific design within an exposure room where EMF level from outer sources is as low as realistically achievable. Because dosimetry and exposure control are key issues in provocation studies, this abstract outlines technical developments and presents the volunteers' exposure assessment.

## **PA-57 [15:00]**

### **Telstra's smart home measurement program in Australia**

Debbie Wills<sup>1</sup>, Sabine Duerr<sup>2</sup>, Mike Wood<sup>1</sup> & Laura Buttle<sup>1</sup>

<sup>1</sup>*Networks, Telstra Corporation, Melbourne, Australia, 3000*

<sup>2</sup>*Narda Safety Test Solutions GmbH, Pfullingen, Germany, 72793*

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Debbie Wills**

Smart home technology already lets us do everything from turn off the iron to check on our pets. With the expectation that there will be around 18 billion connected devices globally by 2022, a large portion of these devices will be used in our homes including security systems, smart appliances, wireless watering systems and smart locks. Telstra has commenced an in-home measurement program to determine typical cumulative RF levels in a residential home. This data will be used to provide our customers with the most up to date information on environmental EME levels from wireless devices.

**PA-59 [15:00]**  
**STUDENT PAPER**

**nsPEFs exposure of liposomes to explore controlled drug delivery applications**

Laura Caramazza<sup>1, 2</sup>, Martina Nardoni<sup>3</sup>, Annalisa De Angelis<sup>1</sup>, Elena della Valle<sup>4</sup>, Agnese Denzi<sup>1</sup>, Patrizia Paolicelli<sup>3</sup>, Caterina Merla<sup>5</sup>, Micaela Liberti<sup>1</sup>, Francesca Apollonio<sup>1</sup> & Stefania Petralito<sup>3</sup>

<sup>1</sup>*ICEmB@DIET, Sapienza University of Rome, Rome, Italy, 00184*

<sup>2</sup>*Center for Life Nano Science@Sapienza, Istituto Italiano di Tecnologia, Rome, Italy, 00161*

<sup>3</sup>*Department of Drug Chemistry and Technology, Sapienza University of Rome, Rome, Italy, 00185*

<sup>4</sup>*Bioelectronic Vision Lab, Biomedical Engineering Department, University of Michigan, Ann Arbor, Michigan State, USA, 2800*

<sup>5</sup>*Division of Health Protection Technologies, ENEA, Rome, Italy, 00123*

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Laura Caramazza**

The increasing interest towards biocompatible nanotechnologies in medicine, combined with electric fields stimulation, is leading to the development of electro-sensitive smart systems for drug delivery applications. Among the known electro-sensitive materials, phospholipids can be used to design nano-sized vesicles suitable for external electric actuation. To this regard, recently the use of pulsed electric fields to trigger release across phospholipid membranes has been numerically studied, for a deeper understanding of the phenomena at the molecular scale. Aim of this work is to give an experimental validation of the feasibility of controlling drug release from liposomes mediated by nanosecond pulsed electric fields.

**PA-61 [15:00]**

**A microdosimetric realistic model to study frequency-dependent AC electroporation in a cell with endoplasmic reticulum**

Annalisa De Angelis<sup>1</sup>, Agnese Denzi<sup>1</sup>, Caterina Merla<sup>2</sup>, Franck Andre<sup>3</sup>, Tomás García-Sánchez<sup>3</sup>, Lluís M. Mir<sup>3</sup>, Francesca Apollonio<sup>1</sup> & Micaela Liberti<sup>1</sup>

<sup>1</sup>*ICEmB at Department of Information Engineering, Electronics and Telecommunications, University of Rome Sapienza, ROMA, Italy, 00184*

<sup>2</sup>*SSPT-Division of Health Protection Technologies, ENEA, ROMA, Italy, 00123*

<sup>3</sup>*Vectorology and Anticancer Therapies-UMR 8203 CNRS, Univ. Paris-Sud, Université Paris-Saclay, Villejuif, France, 94805*

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Annalisa De Angelis**

The study of the frequency-dependent response of a biological cell and its organelles to an intense electric field is of growing interest in the bioelectromagnetic area. The possibility offered by continuous waves to uncouple the effects of the electric field during electroporation is employed in this work using a numerical model including the realistic shape of cell and endoplasmic reticulum membranes. The higher efficiency of the microwave signals in electroporating the subcellular structures, in comparison with the radiofrequency signals, is highlighted.

**PA-63 [15:00]**

**Lactobacillus acidophilus and Escherichia coli inactivation by 600-ns pulsed electric fields**

Stacey Martens<sup>1</sup>, Savannah Klein<sup>1</sup>, Ronald Barnes<sup>1</sup>, Caleb Roth<sup>1</sup> & Bennett Ibey<sup>1</sup>

<sup>1</sup>*Air Force Research Laboratory, Fort Sam Houston, Texas, USA, 78234*

**Keywords: Electroporation, RF/Microwaves, Completed (unpublished)**

**Presented by: Stacey Martens**

Pulsed electric fields (PEF) are utilized as a novel technique to inactivate prokaryotic cells through irreversible electroporation. In this study, we investigated the inactivation effects of 600-ns PEF on *Lactobacillus acidophilus* and *Escherichia coli*.

#### **PA-65 [15:00]**

##### **Mobile phone or tablet use and online activities among children: Results from an internet survey by parents**

Noriko Kojimahara<sup>1</sup>, Yasuto Sato<sup>1</sup> & Masao Taki<sup>2</sup>

<sup>1</sup>*Department of Public Health, Tokyo Women's Medical University, Tokyo, Japan, 1628666*

<sup>2</sup>*Department of Systems Design, Tokyo Metropolitan University, Tokyo, Japan, 1920397*

**Keywords: Epidemiology, RF/Microwaves, Completed (unpublished)**

**Presented by: Noriko Kojimahara**

The aim of this study was to examine whether children's health relates to their mobile phone or tablet device use, and online activities. We conducted an internet survey of 1,545 caregivers living with children aged 0–14 years in Japan to compare the regular use of both mobile phones and tablet devices. The total time using mobile phones was related to age, number of siblings, availability of Wi-Fi at home, and the child's ownership of a mobile phone. Age and availability of Wi-Fi at home were positively related to tablet device use, but both number of siblings and child's ownership of a tablet device were not. The use of a tablet device was related to worse health among preschool children.

#### **PA-67 [15:00]**

##### **Definition of areas of interest in the study of long-term 50 Hz exposure of Brussels inhabitants**

Maryse Ledent<sup>1, 4</sup>, Raf Aerts<sup>1</sup>, Veronique Beauvois<sup>2</sup>, Maxime Spirlet<sup>2</sup>, Christophe Geuzaine<sup>2</sup>, Isabelle Magne<sup>3</sup> & Catherine Bouland<sup>4</sup>

<sup>1</sup>*Risk and Health Impact Assessment, Sciensano, Ixelles, Belgium, 1050*

<sup>2</sup>*Applied and Computational Electromagnetics (ACE), ULiège, Liège, Belgium, 4000*

<sup>3</sup>*Service des Etudes Médicales, EDF, Levallois-Perret Cedex, France, 92309*

<sup>4</sup>*Centre de recherche en santé environnementale et santé au travail, Bruxelles, Belgium, 1070*

**Keywords: Epidemiology, ELF/LF, Work in Progress**

**Presented by: Maryse Ledent**

Fifty-hertz magnetic fields related to the transmission and the distribution of electricity are one of the environmental agents studied in the new BBEMG project on cumulative exposure in the Brussels population. The objectives of the study are to analyse the perceptions, behaviours and health of individuals living in the vicinity of visible and non-visible electrical infrastructure contributing to similar exposures, and to explore links between the visibility of sources and hypersensitivity to 50 Hz magnetic fields. A complementary objective is to compare exposure of people living in areas of dense vs sparse energized electrical infrastructure. This paper will focus on the definition of statistical sectors of interest in Brussels.

#### **PA-69 [15:00] - YOUNG SCIENTIST PAPER**

##### **Perception of health risks from Wi-Fi radiofrequency electromagnetic field exposure: A risk perception study**

Berihun Zeleke<sup>1, 2</sup>, Christopher Brzozek<sup>1, 2</sup>, Chhavi Bhatt<sup>1, 2</sup>, Michael Abramson<sup>1, 2</sup>, Rodney Croft<sup>3</sup>, Frederik Freudenstein<sup>3</sup>, Peter Wiedemann<sup>3</sup> & Geza Benke<sup>1, 2</sup>

<sup>1</sup>*Centre for Population Health Research on Electromagnetic Energy (PRESEE), Monash University, Melbourne, Australia, 3004*

<sup>2</sup>*Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia, 3004*

<sup>3</sup>*Australian Centre for Electromagnetic Bioeffects Research, University of Wollongong, Wollongong, Australia, 2522*

**Keywords: Epidemiology, RF/Microwaves, Completed (unpublished)**

**Presented by: Berihun Zeleke**

People's perceptions towards radiofrequency electromagnetic fields (RF-EMF) exposure and possible health risks are not well understood. We investigated the risk perception of people towards RF-EMF emitted from

Wi-Fi sources in three groups of participants. Before assessment of perception to exposure and risk from Wi-Fi, we provided participants with either basic text, precautionary information, or a summarized personal RF-EMF exposure measurement from Wi-Fi (ISM 2.4 GHz). Subsequently, using a self-administered questionnaire, we assessed exposure perception and risk perception to Wi-Fi. The exposure and risk perception of people towards Wi-Fi differed by the type of information provided prior to assessment of risk perception to RF-EMF.

#### **PA-71 [15:00]**

##### **Monitoring of low frequency magnetic and pulsed electric field biological effects on yeast cells using biological autoluminescence**

Martin Bereta<sup>1</sup>, Michal Teplan<sup>1</sup>, Djamel E. Chafai<sup>2</sup>, Roman Radil<sup>3</sup> & Michal Cifra<sup>2</sup>

<sup>1</sup>*Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, Slovakia (Slovak Republic), 84104*

<sup>2</sup>*Institute of Photonics and Electronics of the Czech Academy of Sciences, Prague, Czech Republic, 18200*

<sup>3</sup>*Faculty of Electrical Engineering and Information Technology, University of Zilina, Zilina, Slovakia (Slovak Republic), 01026*

**Keywords:** *In vitro, ELF/LF, Work in Progress*

**Presented by:** *Martin Bereta*

The aim of presented work is to show the potential application of biological autoluminescence (BAL) for monitoring of electromagnetic field biological effects on yeasts. The yeast cell culture (*Saccharomyces cerevisiae*) is exposed to low frequency magnetic field (800 Hz, 1.5 mT) and pulsed electric field (pulse duration: 1-25  $\mu$ s, electric field strength up to 1 kV.cm<sup>-1</sup>) and the BAL is monitored during exposure. The results indicate detectable differences in BAL dynamics when low frequency magnetic or pulsed electric field is applied. Due to its non-invasive and label-free application, the BAL could be used as a useful tool for monitoring of electromagnetic field biological effects.

#### **PA-73 [15:00]**

##### **Observations of changes in cell growth rates, ROS/RNS and other cellular parameters of HT-1080 cells in weak static magnetic fields**

Hakki Gurhan<sup>1</sup>, Rodolfo Bruzon<sup>1</sup> & Frank Barnes<sup>1</sup>

<sup>1</sup>*Electrical, Computer and Energy Engineering, Boulder, Colorado, USA, 80309*

**Keywords:** *In vitro, Static, Completed (unpublished)*

**Presented by:** *Frank Barnes*

Effects of Weak Static Magnetic Fields (SMF) on cell proliferation and oxidative stress are explored. Upon exposure to magnetic flux densities between 0.5 $\mu$ T to 600 $\mu$ T, calcium influx related metabolic rate changes are observed. Changes in cell plasma membrane potential and intracellular pH levels are also highly related to cell growth rates. In addition, nonlinear changes in oxidative stress are found due to imbalance between pro-oxidants and antioxidants in different SMF exposures. We believe this nonlinear response can be explained with the changes in the free radical concentrations.

#### **PA-75 [15:00]**

##### **Frequency characteristics of neural cell response to electric field exposure by real-time single cell observation**

Masateru Ikehata<sup>1</sup>, Kei Makino<sup>2</sup>, Yukihiisa Suzuki<sup>2</sup>, Atsushi Saito<sup>3</sup>, Sachiko Yoshie<sup>1</sup> & Satoshi Nakasono<sup>3</sup>

<sup>1</sup>*Railway Technical Research Institute, Tokyo, Japan*

<sup>2</sup>*Tokyo Metropolitan University, Tokyo, Japan*

<sup>3</sup>*Central Research Institute of Electric Power Industry, Chiba, Japan*

**Keywords:** *In vitro, ELF/LF, Work in Progress*

**Presented by:** *Masateru Ikehata*

In this study, neural cell response threshold of 10Hz to 50kHz sinusoidal electric field that applied by originally

developed fork shape small electrode was evaluated by originally developed a real-time single cell observation system as alteration of intracellular concentration of Ca<sup>2+</sup>. Similar input voltage of cellular response threshold was observed between 10 to 1,000 Hz. On the other hand, input voltage threshold to induce cellular response was increased depended on frequency from 1 kHz to 50 kHz. Exposure dosimetry of electric field on the surface of cell culture is underway and will be presented at the congress.

#### **PA-77 [15:00]**

##### **The effects of 50 Hz magnetic fields and low dose cadmium co-exposure on cell viability in JEG-3 cells**

Yumin Jin<sup>1</sup>, Aziguli Yimaer<sup>1</sup>, Liling Su<sup>1, 2</sup> & Guangdi Chen<sup>1</sup>

<sup>1</sup>*Bioelectromagnetics Laboratory, Hangzhou, China, 310058*

<sup>2</sup>*Department of Clinical Medicine, Shangrao, China*

**Keywords:** *In vitro, ELF/LF, Work in Progress*

**Presented by:** *Guangdi Chen*

To investigate the effects of 50 Hz magnetic fields (MF) and low dose cadmium co-exposure on cell viability in JEG-3 cells. JEG-3 cells were used as research cell model. The effects of exposure to 50 Hz MF and co-exposure to low dose cadmium and 50 Hz MF on cell viability were examined using CCK-8 assay. Proteomic and metabolomics approaches were applied to further explore the mechanisms of 50 Hz MF influenced cell viability. Under current exposure conditions, 3.0 mT 50 Hz MF may enhance JEG-3 cell viability during a certain time of exposure. The results of proteome and metabolomics profiling will be presented during the conference.

#### **PA-79 [15:00]**

##### **STUDENT PAPER**

##### **Extremely low-frequency weak electromagnetic effects on fibrosarcoma (HT1080) and weak static magnetic field effects on Bacillus Subtilis**

Sahithi Kandala<sup>1</sup>, Mark Hernandez<sup>2</sup> & Frank Barnes<sup>1</sup>

<sup>1</sup>*Electrical, Computer and Energy Engineering, University of Colorado, Boulder, Colorado, USA, 80309*

<sup>2</sup>*Environmental and Civil Engineering, University of Colorado, Boulder, Colorado, USA, 80309*

**Keywords:** *In vitro, ELF/LF, Work in Progress*

**Presented by:** *Sahithi Kandala*

This paper explores the weak extremely-low-frequency electromagnetic effects on Fibrosarcoma cells and static magnetic field effects on Bacillus Subtiliscells. The effects of changes in frequency with constant electromagnetic field strength and changes in the magnetic field strength with constant frequency on growth rate and electron transport chain are discussed.

#### **PA-81 [15:00]**

##### **Impact of exposure at 60 GHz on cellular metabolism of HaCaT keratinocytes**

Pierre Le Pogam<sup>1, 3</sup>, Morgane Lebosq<sup>2</sup>, Yann Le Page<sup>2</sup>, Denis Habauzit<sup>2</sup>, Maxim Zhadobov<sup>1</sup>, Ronan Sauleau<sup>1</sup>, Yves Le Dréan<sup>2</sup> & David Rondeau<sup>1</sup>

<sup>1</sup>*Univ Rennes, CNRS, IETR (Institut d'Électronique et de Télécommunication de Rennes), UMR 6164, Rennes, France, 35000*

<sup>2</sup>*Univ Rennes, INSERM, IRSET (Institut de recherche en santé, environnement et travail), UMR 1085, Rennes, France, 35000*

<sup>3</sup>*Present adress: Équipe "Pharmacognosie-Chimie des Substances Naturelles", BioCIS, Univ. Paris-Sud, CNRS,, Université Paris-Saclay, Châtenay-Malabry, France, 922290*

**Keywords:** *In vitro, RF/Microwaves, Completed (unpublished)*

**Presented by:** *Morgane Lebosq*

Human keratinocytes were in vitro exposed to millimeter waves (MMW at 60.4 GHz) with an incident power density of 20 mW/cm<sup>2</sup>, which correspond to the upper local exposure limit for general public. After a 24h-

exposure, endo- and extracellular extracts were performed and submitted to ultrahigh performance liquid chromatography coupled to high resolution mass spectrometry for analysis. Data analysis show a very limited number of altered features in intracellular metabolomic, whereas important dysregulations could be found in extracellular metabolomic profiles, suggesting that excretion or loss of permeability may occur under MMW exposure.

#### **PA-83 [15:00]**

##### **Effect of exposure to intermediate frequency at 85kHz in cultured human cells**

Eijiro Narita<sup>1</sup>, Shin Koyama<sup>1</sup>, Yoko Shimizu<sup>1</sup>, Naoki Shinohara<sup>1</sup> & Junji Miyakoshi<sup>1</sup>

<sup>1</sup>Laboratory of Applied Radio Engineering for Humanosphere, Kyoto University, Uji, Japan, 611-0011

**Keywords:** *In vitro*, IF, Work in Progress

**Presented by:** Eijiro Narita

We developed an exposure apparatus that generates an intermediate frequency at 85 kHz. This device has already been confirmed that retains a normal culture environment without any artefact. We then performed exhaustive gene analysis by an RNA sequence which is a standard cell experiment method widely used as safety evaluation. As a result of examining gene expression variability by an RNA sequence, there is no effect of the 85 kHz EMF wave in CCD32Sk, HDFa, XP2SA and AT2KY cells.

#### **PA-85 [15:00]**

##### **Broadband exposure systems for *in vitro* and *ex vivo* experiments**

Alessandra Paffi<sup>1, 2</sup>, Alessandro Banin<sup>1</sup>, Agnese Denzi<sup>1</sup>, Maura Casciola<sup>3</sup>, Micaela Liberti<sup>1, 2</sup> & Francesca Apollonio<sup>1, 2</sup>

<sup>1</sup>Department of Information Engineering, Electronics and Telecommunications (DIET), Sapienza University of Rome, Rome, Italy

<sup>2</sup>ICEmB, Genova, Italy

<sup>3</sup> Frank Reidy Research Center for Bioelectrics, Old Dominion University, Norfolk, VA, USA

**Keywords:** *In vitro*, Pulsed, Completed (unpublished)

**Presented by:** Alessandra Paffi

Two different systems for exposing *in vitro* and *ex vivo* biological samples to electromagnetic (EM) fields in the microwave range have been developed. Both of them are broadband and suitable for real-time experiments. The two systems have been compared in terms of their performance numerically and experimentally evaluated.

#### **PA-87 [15:00]**

##### **Real-time detection of IF-MF exposure-induced neuronal response using non-conductive fiber-optic imaging system**

Atsushi Saito<sup>1</sup>, Tatsuya Terai<sup>2</sup>, Kei Makino<sup>2</sup>, Masayuki Takahashi<sup>1</sup>, Sachiko Yoshie<sup>3</sup>, Masateru Ikehata<sup>3</sup>, Yasuhiko Jimbo<sup>4</sup>, Keiji Wada<sup>2</sup>, Yukihiisa Suzuki<sup>2</sup> & Satoshi Nakasono<sup>1</sup>

<sup>1</sup>Biological Environment Sector, Central Research Institute of Electric Power Industry (CRIEPI), Abiko, Japan, 270-1194

<sup>2</sup>Department of Electrical and Electronic Engineering, Tokyo Metropolitan University, Hachioji, Japan, 192-0397

<sup>3</sup>Biotechnology Laboratory, Railway Technical Research Institute (RTRI), Kokubunji, Japan, 2-8-38

<sup>4</sup>Department of Precision Engineering, The University of Tokyo, Bunkyo, Japan, 113-8656

**Keywords:** *In vitro*, IF, Completed (published)

**Presented by:** Atsushi Saito

Threshold values of nerve stimulation associated with exposure to time-varying electromagnetic fields contribute to establish a human protection guidelines. However, biological knowledge about intermediate-frequency magnetic field (IF-MF) are limited. Here, the intracellular calcium ([Ca<sup>2+</sup>]<sub>i</sub>) spikes during 20-kHz IF-

MF exposure in rat brain-derived cultured neurons were evaluated by a novel IF-MF exposure and fiber-optic imaging system. In addition, dosimetry of the induced electrical field in the extracellular solution indicated quantitative differences in the excitation thresholds of neuronal cell bodies and fibers.

#### **PA-89 [15:00]**

##### **The biological effect of the 50 Hz MF-exposed EGF solution on cellular functions in FL cells**

Liling Su<sup>1, 2, 3</sup>, Yue Fei<sup>2</sup>, Yumin Jin<sup>2</sup> & Guangdi Chen<sup>2</sup>

<sup>1</sup>*Department of Clinical Medicine, Shangrao, China*

<sup>2</sup>*Bioelectromagnetics Laboratory, Hangzhou, China*

<sup>3</sup>*Department of Clinical Medicine, Shangrao, China*

**Keywords: *In vitro*, ELF/LF, Completed (unpublished)**

**Presented by: Liling Su**

To explore the biophysical mechanism of ELF-MF induced biological effects, this study examined the effect of 50 Hz MF exposure on the physical properties of biomacromolecules epidermal growth factor (EGF) with phase-interrogation surface plasmon resonance (SPR) sensing. The 30 µg/mL of EGF solution was exposed or sham-exposed to 50 Hz MF at 4.0 mT for 1 h, and the SPR signals were evaluated by the phase-sensitive SPR system. The results showed that exposure to 50 Hz MF at 4.0 mT for 1 h significantly decreased SPR signals of EGF solution. However, we found that 50 Hz MF exposed EGF did not affect the interaction between EGF and EGF receptor (EGFR) *in vitro*, EGF-enhanced cell viability and EGF-induced EGFR clustering in FL cells.

#### **PA-91 [15:00]**

##### **STUDENT PAPER**

##### **Inhibition of bacterial growth by application of small AC electric fields: a study to understand the interaction mechanisms**

Médéric Vindret<sup>1</sup>, Eric Chamberod<sup>2</sup>, Pascal Xavier<sup>1</sup>, Jean Martins<sup>3</sup> & Dominique Rauly<sup>1</sup>

<sup>1</sup>*IMEP-LaHC, CNRS-UGA-GINP-USMB, GRENOBLE, France, 38000*

<sup>2</sup>*GEII, UGA, SAINT MARTIN D'HERES, France, 38400*

<sup>3</sup>*IGE, CNRS-UGA-GINP-IRD, GRENOBLE, France, 38000*

**Keywords: *In vitro*, IF, Work in Progress**

**Presented by: Médéric Vindret**

An innovative process was patented for the inhibition of bacterial growth in liquid media by the application of a low amplitude (< 1V/cm) AC electric field randomly varying into a wide band (10kHz-40MHz). An electrical modeling of the bacterial cell placed in a uniform AC field was carried out in parallel. To refine this modeling, an experimental study of the interaction of small amplitude electric fields with bacteria is described here to understand the origin of growth inhibition. This combines an electric field treatment of the suspension and simultaneous analysis by Electrical Impedance Spectroscopy (EIS). Particular attention has been paid to precisely control the applied electric field. Temperature of the liquid is also measured.

#### **PA-93 [15:00]**

##### **WITHDRAWN**

#### **PA-95 [15:00]**

##### **Non-linear effects on stem cell-mediated regeneration following weak magnetic field (WMF) exposure**

Wendy Beane<sup>1</sup>, Alanna Van Huizen<sup>1</sup>, Luke Kinsey<sup>1</sup> & Frank Barnes<sup>2</sup>

<sup>1</sup>*Department of Biological Sciences, Kalamazoo, MI, USA, 49008-5410*

<sup>2</sup>*Department of Electrical, Computer, and Energy Engineering, Boulder, CO, USA, 80309-0425*

**Keywords: *In vivo*, Static, Work in Progress**

**Presented by: Wendy Beane**

Reactive oxygen species (ROS) play fundamental roles in driving regenerative growth. Previous data showed that 200  $\mu$ T WMFs inhibit ROS at the wound site, reducing stem cell proliferation during planarian regeneration. Our recent data reveal 500  $\mu$ T exposure yields the opposite result, increased growth—similar to directly increasing ROS levels via loss of superoxide dismutase (which increases superoxide anion levels). Our work aims to identify changes in gene expression, proliferation and differentiation with 500  $\mu$ T exposure. Together, the data suggest non-linear responses to different WMF strengths may be useful in designing therapies to either promote (for regenerative medicine) or inhibit (for cancer treatments) cell proliferation.

#### **PA-97 [15:00]**

##### **Behavioral assessment of Alzheimer's transgenic mice following long-term RF exposure**

Ye Ji Jeong<sup>1</sup>, Hyung-Do Choi<sup>2</sup>, Jeong-Ki Pack<sup>3</sup>, Nam Kim<sup>4</sup>, Yun-Sil Lee<sup>5</sup> & Hae-June Lee<sup>1</sup>

<sup>1</sup>*Division of Basic Radiation Bioscience, Korea Institute of Radiological and Medical Sciences, Seoul, Korea*

<sup>2</sup>*Department of EMF Research Team, ETRI, Daejeon, Korea*

<sup>3</sup>*College of Engineering, Chungnam National University, Daejeon, Korea*

<sup>4</sup>*School of Electrical and Computer Engineering, Chungbuk National University, Cheongju, Korea*

<sup>5</sup>*Graduate School of Pharmaceutical Sciences, Ewha Womans University, Seoul, Korea*

**Keywords:** *In vivo, RF/Microwaves, Completed (unpublished)*

**Presented by:** *Hae-June Lee*

To investigate the effect of RF-EMF on neurodegenerative disease, we exposed 5xFAD AD mice to 3, 6 and 8-month RF-EMF and assessed behavioral changes. We found that the RF-EMFs shows improvement of anxiety and memory behaviors in the animal model of Alzheimer's disease, although the significance of the results is different according to the exposure time. The effects of RF-EMF exposure for 6 months or longer were more significant. Especially, the 8-month exposure to RF-EMFs significantly improved brain function such as memory loss and brain glucose metabolism accompanied by beta -amyloid Alzheimer 's disease.

#### **PA-99 [15:00]**

##### **Effects of high intensity local exposure of a 10 GHz-electromagnetic field on glial activity in rat brain**

Hiroshi Masuda<sup>1</sup>, Itsuki Kageyama<sup>1, 2</sup>, Tatsuya Ishitake<sup>1</sup>, Akimasa Hirata<sup>2</sup>, Sachiko Kodera<sup>2</sup>, Takuji Arima<sup>3</sup>, Yasutaka Murakami<sup>3</sup> & Yoshitaka Morimatsu<sup>1</sup>

<sup>1</sup>*Department of Environmental Medicine, Kurume University School of Medicine Kurume, Kurume, Japan, 830-0011*

<sup>2</sup>*Department of Computer Science and Engineering, Nagoya Institute of Technology, Nagoya, Japan, 466-8555*

<sup>3</sup>*Department of Computer Science and Engineering, Tokyo University of Agriculture and Technology, Tokyo, Japan, 184-8588*

**Keywords:** *In vivo, RF/Microwaves, Work in Progress*

**Presented by:** *Hiroshi Masuda*

The possibility of radio-frequency electromagnetic fields (RF-EMF) of mobile phones to cause any adverse health effects on the brain is a subject of numerous studies and publications. However, the intensity level of RF-EMF exposure, which can occur the activation of glial cells, is still arguable. Aim of the present study was to investigate a threshold of the local exposure intensity of RF-EMF for the activation of glial cells. We found that obvious morphological difference between sham-exposed and exposed animals in both glial cells 3 days after the RF-EMF exposure under high intensity exposure conditions.

#### **PA-101 [15:00]**

##### **In vivo assessment of genotoxicity for high intensity intermediate-frequency magnetic fields exposure**

Shin Ohtani<sup>1</sup>, Akira Ushiyama<sup>2</sup>, Keiji Wada<sup>3</sup>, Yukihisa Suzuki<sup>3</sup>, Kazuyuki Ishii<sup>1</sup> & Kenji Hattori<sup>1</sup>

<sup>1</sup>*Department of Hygienic Chemistry, Meiji Pharmaceutical University, Kiyose, Japan, 204-8588*

<sup>2</sup>Department of Environmental Health, National Institute of Public Health, Wako, Japan, 351-0197

<sup>3</sup>Graduate School of Science and Engineering, Tokyo metropolitan University, Hachioji, Japan, 192-0397

**Keywords:** *In vivo*, *IF*, *Work in Progress*

**Presented by:** *Shin Ohtani*

Intermediate frequency magnetic fields (IF-MFs) at around 85 kHz are a component of wireless power transfer (WPT) systems. To explore the possible genotoxic effects of IF-MF, we developed the system of high intensity intermittent IF-MF exposure. Pig-a assay and micronucleus test were performed in the mice blood sampled after IF-MF exposure. We found that there was no significant change in the ratio of Pig-a mutated erythrocytes and the micronucleus-containing erythrocytes after intermittent IF-MF exposure for one day (1hr/day). In addition, we are examining the Pig-a assay and the micronucleus test after 10 days (1hr/day) IF-MF exposure. Results are currently under analysis and will be shown in our presentation.

#### **PA-103 [15:00]**

##### **Thermoelastic pressure transients generated by High Peak Power pulsed radiofrequency exposures can induce Heat Shock Protein 70 up-regulation in mice**

Caleb Roth<sup>1</sup>, Cesario Cerna<sup>2</sup>, Benjamin Kasokonis<sup>2, 3</sup>, Kaitlin Nelson<sup>1</sup>, Jeffrey Whitmore<sup>1</sup>, Bennett Ibey<sup>1</sup>, Ronald Barnes<sup>1</sup>, Christopher Valdez<sup>1</sup> & Jason Payne<sup>1</sup>

<sup>1</sup>Radio Frequency Bioeffects Branch, Air Force Research Laboratory, San Antonio, TX, USA, 78234

<sup>2</sup>General Dynamics IT, San Antonio, TX, USA, 78234

<sup>3</sup>Army Research Laboratory, San Antonio, TX, USA, 78234

**Keywords:** *In vivo*, *RF/Microwaves*, *Work in Progress*

**Presented by:** *Caleb Roth*

Modeling and simulation of HPP exposures on rodents suggests that certain HPP systems are capable of generating thermoelastic pressure transients of a sufficient magnitude to cause damage to cellular proteins within the rodent. To validate these models, we used the transgenic mouse model (FVB/NJ-Tg(Hspa1a-luc,-EGFP)2Chco/J) to detect potential mechanical stress *in vivo*. Our data suggests that this transgenic mouse model has the potential to be used as an *in vivo* dosimeter for RF mediated mechanical stress.

#### **PA-105 [15:00]**

##### **STUDENT PAPER**

##### **Acute exposure to cellphone radiofrequency signal: effect on young adolescent rat brain**

Kumari Singh<sup>1, 2</sup>, Rakesh Arya<sup>2, 3</sup>, Jayprakash Nirala<sup>1</sup>, Ranjan Nanda<sup>2</sup> & Paulraj Rajamani<sup>1</sup>

<sup>1</sup>School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India, 110067

<sup>2</sup>Translation Health Group, International Center for Genetic Engineering and Biotechnology, New Delhi, India, 110067

<sup>3</sup>School of Life Sciences, Sambalpur University, Jyoti Vihar, Odisha, India, 768019

**Keywords:** *In vivo*, *RF/Microwaves*, *Work in Progress*

**Presented by:** *Kumari Singh*

Now a days continuous use of cellphone for a long stretch of time are quite common specially among young adolescents, So present study was aimed at assesing effects of long term cellphone radiofrequency exposure on hippocampal redox enveronment and rate of neurogenesis in young adolescent rats.

#### **PA-107 [15:00]**

##### **Exposure to 835 MHz electromagnetic fields cause a down-regulation of tyrosine hydroxylase expression in aging-PD mice model**

Woosun Wang<sup>1</sup>, Ju-Hwan Kim<sup>1</sup>, Hakrim Kim<sup>1</sup>, Hyung-Gun Kim<sup>1</sup> & Jin-Koo Lee<sup>1</sup>

<sup>1</sup>Department of Pharmacology, Dankook University, Cheonan, Korea, 31116

**Keywords:** *In vivo*, *RF/Microwaves*, *Work in Progress*

**Presented by:** *Jin-Koo Lee*

Chronic exposure to RFR in aging-PD mice model cause the reduction of dopamine metabolism in striatum. Dopamine metabolism abnormalities can lead to abnormal behavioral responses in aging-PD animal models.

**PA-109 [15:00]**

**WITHDRAWN**

**PA-111 [15:00]**

**WITHDRAWN**

**PA-113 [15:00]**

**STUDENT PAPER**

**Effects of 50 Hz magnetic field on cutaneous blood flow volume by cold, room temperature and warm water immersion test**

Nur Izyana Faradila Binti Azmi<sup>1</sup>, Hideyuki Okano<sup>2</sup>, Hiromi Ishiwatari<sup>3</sup> & Keiichi Watanuki<sup>1, 2, 4</sup>

<sup>1</sup>*Graduate School of Science and Engineering, Saitama University, Saitama, Japan, 338-8570*

<sup>2</sup>*Advanced Institute of Innovative Technology, Saitama University, Saitama, Japan, 338-8570*

<sup>3</sup>*Soken Medical Co., Ltd., Tokyo, Japan, 171-0033*

<sup>4</sup>*Brain and Body System Science Institute, Saitama University, Saitama, Japan, 338-8570*

**Keywords:** *Human, ELF/LF, Work in Progress*

**Presented by:** *Nur Izyana Faradila Binti Azmi*

This study focuses on the acute influence of 50 Hz magnetic field ( $B_{\max}$  180 mT,  $B_{\text{rms}}$  127 mT for 10 min) on recovery of cutaneous blood flow volume after cold (5°C), room temperature (25°C) and warm (42°C) water immersion for 1 min. In a randomised, double blind and crossover study design, magnetic field (MF) and sham control exposures were carried out with 10 healthy volunteers using a 2D laser speckle flowmetry. Except for the warm water immersion, the results showed that the blood flow recovery rate of part of the fingers was significantly faster and higher under MF exposure. These results suggested that MF could partially restore the reduced blood microcirculation in cold stress-induced ischemic conditions.

**PA-115 [15:00]**

**Design of a metasurfaced phone case for the reduction of specific absorption rate**

Niamat Hussain<sup>1</sup>, Min-Joo Jeong<sup>1</sup>, Ji Woong Park<sup>1</sup>, Hanul Bong<sup>1</sup> & Nam Kim<sup>1</sup>

<sup>1</sup>*College of Electrical and Computer Engineering, Chungbuk National University, Cheongju-si, Korea, 28644*

**Keywords:** *Human, RF/Microwaves, Work in Progress*

**Presented by:** *Min-Joo Jeong*

This paper presents the design of a mobile phone case by employing a metasurface for the reduction of Specific Absorption Rate (SAR) for the 5G mobile devices operating at 3.5 GHz. The simulation results show that the SAR is significantly reduced when the antenna in the phone housing is incorporated with the metasurfaced phone case. The SAR value for 1 g with a normal phone is noted to be 0.8 W/kg, which is reduced to 0.5 W/kg for the phone case with the metasurface. The proposed method does not only provide an effective way to suppress 5G mobile phone radiation exposure but also invites more researchers to work on metasurfaced phone cases to minimize increased health risks in the 5G mobile communication.

**PA-117 [15:00] - YOUNG SCIENTIST PAPER**

**50 Hz electric field effect on heart rate variability**

Tarmo Koppel<sup>1</sup> & Inese Vilcane<sup>1</sup>

<sup>1</sup>*Department of Labor Environment and Safety, Tallinn University of Technology, Tallinn, Estonia* **Keywords:**

*Human, ELF/LF, Work in Progress*

**Presented by:** *Tarmo Koppel*

This study exposed subjects (N=60) to 50 Hz sinusoidal electric field at 1500-2000 V m<sup>-1</sup>. The exposure was focused at the feet. The exposure set-up represented a typical office workstation scenario, where workers would place their feet on top of the power wires. The test was done under blind test conditions, consisting of five stages, including control and exposure stages, each lasting for about two minutes. The exposure took place in two stages. The results show, the average heart rate increased due course of the test. In addition, the total power of the heart rate variability (HRV) was statistically significantly lower during exposure stages than control stages.

#### **PA-119 [15:00]**

##### **Towards personalized treatment for TMS: Reducing the segmentation time**

Maria Tzirini<sup>1</sup>, George Tsanidis<sup>1</sup>, Ioannis Markakis<sup>1</sup>, Yiftach Roth<sup>2, 3</sup> & Theodoros Samaras<sup>4, 5</sup>

<sup>1</sup>*THESS S.A., Thessaloniki, Greece, 57001*

<sup>2</sup>*Department of Life Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

<sup>3</sup>*Brainsway Ltd., Jerusalem, Israel*

<sup>4</sup>*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece, 54124*

<sup>5</sup>*Department of Physics, University of Malta, Msida, Malta*

**Keywords: Human, ELF/LF, Work in Progress**

**Presented by: Theodoros Samaras**

In order to apply personalized treatment for TMS, the segmentation time needs to be reduced. A method which uses fewer tissues models has been developed and its results have been validated with the use of three full-tissue high-resolution ViP models. The results are compared in terms of electric field distribution, induced by a Hased coil in the cerebral tissues, and its maximum value. Moreover, the necessity of the dura mater design in the fewer tissue models is discussed.

#### **PA-121 [15:00]**

**WITHDRAWN**

#### **PA-123 [15:00]**

##### **Transprotein-electropore characterization: A molecular dynamics investigation on human AQP4**

Paolo Marracino<sup>1</sup>, Mario Bernardi<sup>1</sup>, Micaela Liberti<sup>1</sup>, Federico Del Signore<sup>1</sup>, Josè Antonio Garate<sup>3</sup>, Christian Burnham<sup>2</sup>, Francesca Apollonio<sup>1</sup> & Niall English<sup>2</sup>

<sup>1</sup>*DIET, University of Rome "La Sapienza", Rome, Italy*

<sup>2</sup>*School of Chemical and Bioprocess Engineering, University College Dublin, , Valparaiso, Ireland*

<sup>3</sup>*Centro Interdisciplinario de neurociencia de Valparaiso, Universidad de Val, Valparaiso, Chile*

**Keywords: Mechanistic/Theoretical, Static, Completed (published)**

**Presented by: Francesca Apollonio**

Electroporation characterization is a topic of intensive interest probed by extensive ongoing research efforts. Usually, these studies are carried out on lipid-bilayer electroporation. Surprisingly, the possibility of water-channel electropore formation across transmembrane proteins themselves, particularly in view of such a promising application, has not yet been elucidated. The present work examines the geometrical and kinetic aspects of electropores and their stability in such a protein milieu.

#### **PA-125 [15:00]**

**STUDENT PAPER**

##### **Experimental model simulation on electromagnetic wave therapy of apical periodontitis**

Hideo Taketani<sup>1</sup>, Masatake Akutagawa<sup>2</sup>, Hiromichi Yumoto<sup>3</sup>, Kouji Hirao<sup>3</sup>, Takahiro Emoto<sup>2</sup>, Hiroo Tarao<sup>4</sup>, Toshihiko Tominaga<sup>5</sup>, Toshitaka Ikehara<sup>6</sup> & Yohsuke Kinouchi<sup>2</sup>

<sup>1</sup>*Department of Electrical and Electronic Engineering, Graduate School of Advanced Technology and*

Science, Tokushima University, Tokushima, Japan, 770-8506

<sup>2</sup>Graduate School of Technology, Industrial and Social Sciences, Tokushima University, Tokushima, Japan, 770-8506

<sup>3</sup>Department of Periodontology and Endodontology, Tokushima University, Tokushima, Japan, 770-8504

<sup>4</sup>Department of Electrical and Computer Engineering, Kagawa National College of Technology, Takamatsu, Japan, 761-8058

<sup>5</sup>Tominaga Dental Clinic, Naruto, Japan, 771-0360

<sup>6</sup>Department of Human Welfare, Tokushima Bunri University, Tokushima, Japan, 770-8514

**Keywords: Mechanistic/Theoretical, IF, Work in Progress**

**Presented by: Hideo Taketani**

The major current treatment of the apical periodontitis is cleaning of the root canal with chemicals. Recently EMAT(electro-magnetic apical treatment) have been proposed. EMAT is a treatment for sterilizing the root canal and regenerating the alveolar bone by applying voltage into the root canal. Although the experiment about the effect with EMAT is currently performed, the current density distribution in the experimental environment is still unknown. Thus, a experimental model was created and the current density distribution was obtained by simulation. As a result, it was thought that heat by applying voltage was transferred by convection from the electrode tips to the outside of the electrodes, and it was distributed to the whole PBS.

**PA-127 [15:00]**

**WITHDRAWN**

**PA-129 [15:00]**

**WITHDRAWN**

**PA-131 [15:00]**

**Interference of cardiac devices by electronic article surveillance systems - Still a problem?**

Carsten Alteköster<sup>1</sup>, Ingo Bömmels<sup>1</sup> & Corinna Becker<sup>2</sup>

<sup>1</sup>Unit Radiation, IFA, Sankt Augustin, Germany, 53757

<sup>2</sup>Prevention, BGHW, Mannheim, Germany, 68161

**Keywords: Occupational, All Frequencies, Work in Progress**

**Presented by: Carsten Alteköster**

Many employees, who are insured by the German Social Accident Insurance Institution for the trade and distribution industry (BGHW), are working in the retail industry and are exposed to electromagnetic fields (EMF) from electronic article surveillance (EAS) systems in their workplace. For the mandatory competent risk assessment of those, the Institute of Occupational Safety and Health (IFA) supported the BGHW by carrying out measurements at various currently used EAS systems. Although it is known, that EAS systems can emit EMF at a level that are possibly hazardous for employees with or without implanted cardiac devices [1, 2], it was found that these systems are still in use. Hence, there is a need of action for preventive measures.

**PA-133 [15:00]**

**Evaluation of electromagnetic exposure during the use of induction hobs in ergonomically realistic numerical modeling**

Krzysztof Gryz<sup>1</sup>, Jolanta Karpowicz<sup>1</sup> & Patryk Zradziński<sup>1</sup>

<sup>1</sup>Laboratory of Electromagnetic Hazards, Central Institute for Labour Protection - National Res. Inst. (CIOP-PIB), Warszawa, Poland, 00-701

**Keywords: Occupational, IF, Work in Progress**

**Presented by: Jolanta Karpowicz**

The exposure to electromagnetic field (EMF) emitted by studied induction hob (maximum 1.8 kW power, 25

kHz frequency) were evaluated by measurements and numerical simulations of the electric field ( $E_{in}$ ) induced in the tissues of females body models. The results of ongoing study shown e.g. that  $E_{in}$  values in the body 5 cm away from the induction hob heating coil approach general public exposure limit values in case the magnetic field strength is higher than 11 A/m (such exposure condition exists up to 20 cm from heating zone covered by pot in centred position). In order to prevent potential exposures exceeding safety limits, the use of induction hobs in the work place needs to involve technical or organisational protection measures.

#### **PA-135 [15:00]**

##### **Evaluation of exposures to electromagnetic radiofrequency radiation from radio communication devices and systems in suburbs of medical resort function in Poland**

Jolanta Karpowicz<sup>1</sup> & Krzysztof Gryz<sup>1</sup>

<sup>1</sup>Laboratory of Electromagnetic Hazards, Central Institute for Labour Protection - National Res. Inst. (CIOP-PIB), Warszawa, Poland, 00-701

**Keywords: Occupational, RF/Microwaves, Completed (unpublished)**

**Presented by: Jolanta Karpowicz**

Exposure to electromagnetic radiofrequency radiation (ERR) from RTV, mobile telephony, Internet access, etc. (whole-body exposure, WBE, from system antennas; and localized exposure, LE, from portable terminals) was evaluated by: broadband measurements of ERR spatial distribution, spectrum measurements and frequency-selective estimation of its variability. In the three large urban centers and their suburbs of medical resort's function in Poland measurements showed average ERR in particular urban and suburb locations, respectively [V/m]: 0.3-0.5/0.10; 0.6-1.2/0.15; 0.5-1.2/0.05; in the urban centers: LE at least 3-times lower than WBE, and in the resort's suburbs: LE at least 5-times lower than WBE.

#### **PA-137 [15:00]**

##### **Evaluation of in situ electric fields and tissue warming in proximity to metallic implants for low to intermediate frequency magnetic field exposure at workplace**

Rene Hirtl<sup>1</sup>, Klaus Schiessl<sup>2</sup>, Richard Überbacher<sup>1</sup>, Tobias Jhala<sup>1</sup> & Gernot Schmid<sup>1</sup>

<sup>1</sup>EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, 2444

<sup>2</sup>Austrian Workers' Compensation Board (AUVA), Vienna, Austria, 1200

**Keywords: Occupational, ELF/LF, Completed (unpublished)**

**Presented by: Klaus Schiessl**

Although within workplace legislation, such as EU-Directive 2013/35/EU, enhanced risks due to metallic implants need to be accounted for, only few systematic reviews exist. Evaluation against the exposure limit values of 2013/35/EU up to 10MHz has been performed under consideration of abundant metallic implants. Risk of nerve stimulation and tissue warming due to heating of the metallic implant itself has been evaluated with numerical simulations. Several experiments with inductions heaters in the frequency range up to 100kHz have been conducted for validation. Reduction factors, to be applied on action levels of 2013/35/EU, have been found, ensuring compliance with the underlying exposure limit values for workers with metallic implants.

#### **PA-139 [15:00]**

##### **Analyses of background factors on allocating MRI scan duties to pregnant employees**

Sachiko Yamaguchi-Sekino<sup>1</sup>, Humio Maeyatsu<sup>2</sup>, Tsukasa Doi<sup>3</sup>, Takeo Hikichi<sup>4</sup>, Hideki Fujita<sup>5</sup>, Shinya Imai<sup>6</sup>, Manabu Akahane<sup>7</sup>, Shuhei Izawa<sup>1</sup> & Rui-Sheng Wang<sup>1</sup>

<sup>1</sup>National Institute of Occupational Safety and Health, Japan, Kawasaki, Japan, 2148585

<sup>2</sup>Izumi Hospital, Sendai, Japan, 9813212

<sup>3</sup>Takai Hospital, Tenri, Japan, 6320006

<sup>4</sup>Hirose Hospital, Sendai, Japan, 9893121

<sup>5</sup>Osaka Saiseikai Nakatsu Hospital, Osaka, Japan, 5300012

<sup>6</sup>Faculty of Health Sciences, Butsuryo College of Osaka, Osaka, Japan, 5938328

<sup>7</sup>Department of Public Health, Health Management and Policy, Nara Medical University, Kashihara, Japan, 6348521

**Keywords: Occupational, Static, Completed (published)**

**Presented by: Sachiko Yamaguchi-Sekino**

In our previous study, we sent 5763 questionnaires to facilities equipped with MRI devices in Japan in order to survey their policies on allocating MRI scan duties to pregnant employees. This study analyzed background factors in duty allocation, particularly the “less-promoted allocation pattern” choice for pregnant employees. Classification tree modeling and binomial logistic regression analyses showed that concerns of adverse health effects caused by non-ionizing radiation (NIR) exposure were strong motivations in deciding a pregnant employee’s allocation. Views on exposure to NIR and concerns of physical load also played an important role in the decision-making process.

#### **PA-141 [15:00]**

##### **Examples of magnetic field measurements in two electric cars**

Rauno Pääkkönen<sup>1</sup> & Leena Korpinen<sup>2</sup>

<sup>1</sup>TMI Rauno Pääkkönen , Tampere, Finland

<sup>2</sup>Clinical Physiology and Neurophysiology Unit , The North Karelia Central Hospital , Joensuu, Finland

**Keywords: Public Health Policy, ELF/LF, Completed (published)**

**Presented by: Leena Korpinen**

Smart cities contain various electromagnetic field sources, e.g., electric cars (EVs) and the charging technology of EVs. We have performed this work on sample measurements of electric cars related to electromagnetic exposures. The fields have generally been less than the recommended values.

#### **PA-143 [15:00]**

##### **A role for learned societies in promoting good scientific practice and open science**

Andrew Wood<sup>1, 3</sup> & Robert McIntosh<sup>1, 2, 3</sup>

<sup>1</sup>School of Health Sciences, Swinburne University of Technology, Melbourne, Australia, Vic 3122

<sup>2</sup>Telstra Research Labs., Telstra, Melbourne, Australia, Vic 3000

<sup>3</sup>Australian Centre for Electromagnetic Bioeffects Research, Melbourne, Australia, Vic 3122

**Keywords: Public Health Policy, RF/Microwaves, Review, Commentary, Recommendation, Evaluation**

**Presented by: Andrew Wood**

Inconsistency of outcomes has long been a feature of bioelectromagnetics research. Learned societies (e.g. BEMS) and associated journals, can play a role in promoting good practices, in order to set out and reduce areas of uncertainty. The society webpage in particular can provide a portal to useful experimental resources and advice on experimental design, particularly in regard to dosimetry, methodology and data analysis. It can also provide access to facilities for data repository, pre-registration of protocols and open source computer codes. The journal Bioelectromagnetics can also provide similar resources (and has). The purpose of this poster is to stimulate further discussion in this area and to collect feedback from viewers.

#### **PA-145 [15:00]**

##### **Comparison of SARs measured by vector probe array-based SAR measurement systems using commercially available smartphones**

Tomoaki Nagaoka<sup>1</sup>, Kanako Wake<sup>1</sup> & Soichi Watanabe<sup>1</sup>

<sup>1</sup>National Institute of Information and Communications Technology, Tokyo, Japan, 184-8795

**Keywords: Standards, RF/Microwaves, Work in Progress**

**Presented by: Tomoaki Nagaoka**

SAR measurement is indispensable for testing the compliance of wireless communication products with safety limits. The procedures of SAR measurement are established by the international standards. In these standards, SAR should be measured in all possible measurement settings, which are combinations of

frequencies and device positions. Since a conventional SAR measurement method requires a great deal of time, a vector probe array-based SAR measurement system has recently been developed as a next-generation SAR measurement system. In this study, we measured the SARs of the latest smartphones using two types of vector probe array-based SAR measurement system and compared the SARs measured by these two systems as a basic study.

**PA-147 [15:00]**

**Probability of Injury from Radio Frequency Exposure (PIRE): Categorizing the hazards of superficial RF insults**

Jeffrey Whitmore<sup>1</sup>, William Voorhees<sup>1</sup> & Jason Payne<sup>1</sup>

<sup>1</sup>*Radio Frequency Bioeffects Branch, Air Force Research Laboratory, San Antonio, Texas, USA, 78234*

**Keywords: Standards, RF/Microwaves, Work in Progress**

**Presented by: Jeffrey Whitmore**

Modeled thermal profile of various superficially penetrating radio frequency exposures. Collected exposure data for radio frequency (RF) exposures on excised swine skin at several different incidence angles and compared to model predictions. Related the predictions and observations to standards and damage metrics. Used this information to inform a hazard construct for superficially penetrating RF systems.

**Session: FB**  
**Student Flash Poster Session B**  
**Tuesday June 25, 2019 • 14:00 - 15:00**  
**Einstein**  
**Chairs: Christopher Portier & Niels Kuster**

**FB-1 [14:00]**  
**STUDENT PAPER**

**Three dimensional microdosimetry study at millimeter waves**

Zain Haider<sup>1</sup>, Maxim Zhadobov<sup>1</sup>, Yves Le Dréan<sup>2</sup> & Ronan Sauleau<sup>1</sup>

<sup>1</sup>*Univ Rennes, CNRS, IETR – UMR 6164, F-35000 Rennes, France*

<sup>2</sup>*Univ Rennes, Inserm, EHESP, IRSET (Institut de recherche en santé, environnement et travail) – UMR\_S 1085, F-35000 Rennes, France*

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**

**Presented by: Zain Haider**

A microdosimetric study is performed on biological cells models in the 60 GHz band. Complex permittivity data of dielectric models of the membrane, cytoplasm, and extracellular medium at microwaves have been extrapolated to millimeter-wave frequencies. A quasi-static electromagnetic (EM) analysis is employed to solve the Laplace equation both analytically and numerically. Preliminary results provide insight into millimeter-wave power deposition at the sub-cellular level.

**FB-2 [14:03]**  
**STUDENT PAPER**

**Characteristics of temperature rise in a human eyeball due to a dipole antenna in frequency range from 6 GHz to 30 GHz**

Shugo Nishikawa<sup>1, 2</sup>, Tomoaki Nagaoka<sup>2</sup>, Soichi Watanabe<sup>2</sup>, Ryosuke Suga<sup>1</sup>, Kanako Wake<sup>2</sup> & Osamu Hashimoto<sup>1</sup>

<sup>1</sup>*Graduate School of Science and Engineering, Sagamihara, Japan, 252–5258*

<sup>2</sup>*National Institute of Information and Communication, Koganei, Japan, 184-8795*

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**

**Presented by: Shugo Nishikawa**

Recently, the use of smartphones and tablet terminals for data communication has increased. For 5G, data communication via mobile terminals is expected to increase more than ever. In a frequency band above 6 GHz, the electromagnetic energy is mainly absorbed on the surface of the human body. Therefore, we focused on the temperature in the eyeball and its surroundings by placing a wireless communication terminal in front of the eyes. In this study, we estimated the temperature rise in the eyeball due to a half-wavelength dipole antenna in a frequency range from 6 GHz to 30 GHz located close to a human eye using an anatomical model with high fidelity and high resolution.

**FB-3 [14:06]**  
**STUDENT PAPER**

**Measurement campaign for the assessment of electromagnetic fields near cellular base stations in Belgium**

Rachel Nkem Iyare<sup>1</sup>, Vladimir Volskiy<sup>1</sup> & Guy A.E Vandenbosch<sup>1</sup>

<sup>1</sup>*Electrical Engineering, Katholieke Universiteit, Leuven, Belgium, 3001*

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (unpublished)**

**Presented by: Rachel Nkem Iyare**

The electromagnetic radiation emitted by cellular base stations in Belgium is measured. The objective of this assessment is to provide the relevant information on electromagnetic fields produced by cellular base stations and to investigate the changes of electromagnetic exposure within a typical day and over multiple

days in the vicinity of these base stations. The measurements were performed using highly precise measurement equipment in public areas comprising different locations. The exposure was carried out for mobile communication networks. The results show that all analyzed locations are in compliance with the exposure limits recommended by ICNIRP and that the exposure levels are reproducible over a time span of ca. one month.

#### **FB-4 [14:09]**

##### **STUDENT PAPER**

#### **Dosimetric study of electrophysiological recording devices based on micro-electrodes under Radio-Frequency exposures**

Amani Nefzi<sup>1</sup>, Clement E. Lemerrier<sup>2</sup>, Noëlle Lewis<sup>2</sup>, Isabelle Lagroye<sup>2, 3</sup>, Philippe Leveque<sup>1</sup> & Delia Arnaud-Cormos<sup>1</sup>

<sup>1</sup>*Univ. Limoges, CNRS, XLIM, UMR 7252, Limoges, France, 87000*

<sup>2</sup>*Univ. Bordeaux I, CNRS, IMS, UMR 5218, Talence, France, 33400*

<sup>3</sup>*Paris "Sciences et Lettres" Research University, EPHE, Paris, France*

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Amani Nefzi**

In this work, recording devices based on micro-electrodes were developed to study the electrical activity of neurons while exposed to RF fields. The exposure system used for RF application is a Transverse Electromagnetic (TEM) cell. An RF exposure setup is described, the results of the experimental dosimetry of the two micro-electrodes recording devices are explored. Experimental dosimetry proved that TEM cell containing the micro-electrodes devices has a good energy transfer with a return loss under -10 dB the frequency band up to 3 GHz. Applying 5 W for 30 minutes to 1 mL of biological medium within the micro-electrode device induced a temperature elevation of around 1.5°C.

#### **FB-5 [14:12]**

##### **STUDENT PAPER**

#### **Microsecond kinetics of ion transport and interface binding in electrically stressed phospholipid bilayers**

Federica Castellani<sup>1, 2</sup>, Esin B Sözer<sup>1</sup> & P. Thomas Vernier<sup>1</sup>

<sup>1</sup>*Frank Reidy Research Center for Bioelectrics, Norfolk, Va, USA, 23508*

<sup>2</sup>*Biomedical Engineering, Frank Batten College of Engineering and Technology, Norfolk, Va, USA, 23508*

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Federica Castellani**

Formation of bilayer-spanning water bridges and conductive lipid pores is enhanced by the application of transmembrane electric fields. Drugs, nucleic acids, and other normally impermeant material can enter cells through these lipid electropores. The mechanisms underlying this process, called electroporation or electropermeabilization, are not well understood. Molecular dynamics simulations of lipid membranes in electric fields can be used to investigate this phenomenon at the experimentally inaccessible nanoscale. Here we describe the previously unexplored microsecond kinetics of ion binding to phospholipid bilayers and transport through lipid electropores in double bilayer systems containing K<sup>+</sup>, Ca<sup>2+</sup>, and Cl<sup>-</sup>.

#### **FB-6 [14:15]**

##### **STUDENT PAPER**

#### **Development of estimation model for exposure of magnetic field at intermediate frequency from household induction cooker**

Takumi Kitajima<sup>1</sup>, Akemi Morita<sup>1</sup>, Wakaha Ikeda<sup>2</sup>, Mukaide Takahiro<sup>1</sup>, Yoshikazu Matsuda<sup>1</sup>, Amexo Jennifer<sup>1</sup>, Kuurdor Deku-Mwin<sup>1</sup>, Thida Win<sup>1</sup>, Masao Taki<sup>3</sup> & Shigeru Sokejima<sup>1, 2</sup>

<sup>1</sup>*Department of Public Health and Occupational Medicine, Tsu City, Japan, 514-8507*

<sup>2</sup>*Epidemiology Centre for Disease Control and Prevention, Mie University Hospital, Tsu City, Japan, 514-0001*

<sup>3</sup>*Department of Electrical and Electronic Engineering, Hachioji City, Japan, 192-0397*

**Keywords:** *Epidemiology, IF, Work in Progress*

**Presented by:** *Takumi Kitajima*

Epidemiological studies have not yet been conducted to investigate health effects due to exposure of electromagnetic fields at the intermediate frequency (IF) band. As a first step this study, we tried to develop an IF exposure estimation model from Induction cooker in the home environment. As a result, it was found that the distance relation from the hob, diameter of cooking pan, heat power wattage, width of heater housing greatly contributed. Also, the current model tends to lose accuracy as the estimate of high value becomes higher. The future task is to examine question sentences to accurately answer the positional relationship with the body surface.

**FB-7 [14:18]**

**STUDENT PAPER**

**Biohacking *in vitro* wound healing models with electrotherapy**

Jerome Hunckler<sup>1</sup>, Lucien Bartram<sup>3</sup>, Janice Tsui<sup>1</sup> & Brian Cousins<sup>2</sup>

<sup>1</sup>*University College London, London, United Kingdom, NW3 2PS*

<sup>2</sup>*Department of Chemistry, Loughborough University, Loughborough, United Kingdom, LE11 3TU*

<sup>3</sup>*Globe Microsystems Ltd, Esher, United Kingdom, KT10 8BL*

**Keywords:** *In vitro, Static, Work in Progress*

**Presented by:** *Jerome Hunckler*

Wounded skin possesses a specific pattern of electrical activity called current of injury that is essential to healing. Applying electrical stimulation on chronic wounds may mimic the natural current of injury and enhance regeneration. The overall aim of this study is to set up a model of a cutaneous injury *in vitro*, optimize the electrical stimulation parameters on this model using human dermal fibroblasts, and investigate the behaviour of cells derived from patient with specific diseases under optimised direct current, pulsed current and Naturepulse® clinical device (Globe Microsystems Ltd, UK).

**FB-8 [14:21]**

**STUDENT PAPER**

**Manipulation of weak magnetic fields alters stem cell proliferation during regeneration**

Alanna Van Huizen<sup>1</sup>, Luke Kinsey<sup>1</sup>, Frank Barnes<sup>2</sup> & Wendy Beane<sup>1</sup>

<sup>1</sup>*Department of Biological Sciences, Western Michigan University, Kalamazoo, Michigan, USA, 49008-5410*

<sup>2</sup>*Department of Electrical, Computer, and Energy Engineering, University of Colorado, Boulder, Boulder, Colorado, USA, 80309-0425*

**Keywords:** *In vivo, Static, Completed (published)*

**Presented by:** *Alanna Van Huizen*

Weak magnetic fields (WMFs) can affect the rate of cellular proliferation. Using the planarian regeneration model, we show exposure to 200  $\mu$ T WMFs inhibits new tissue (blastema) growth, as compared to 45  $\mu$ T (earth-normal) controls. Growth inhibition occurred due to loss of reactive oxygen species (ROS) at the wound site, which reduced heat shock protein 70 expression (which in turn is required for stem cell proliferation). Variations in WMFs are thought to change electron spin states in radical molecules, thus affecting radical pair recombination rates. These data reveal that based on field strength, WMF exposure can increase or decrease new tissue formation *in vivo*, suggesting WMFs as a potential tool to manipulate mitotic activity.

**FB-9 [14:24]**

**STUDENT PAPER**

**On the development of an imaging system at mm-wave frequencies for biological applications: dielectric characterization of tissues and first preliminary results on phantoms**

Simona Di Meo<sup>1</sup>, Marco Pasian<sup>1</sup>, Giulia Matrone<sup>1</sup>, Lorenzo Pasotti<sup>1</sup>, Lourdes Farrugia<sup>2</sup> & Charles Sammut<sup>2</sup>

<sup>1</sup>*Department of Electrical, Computer and Biomedical Engineering, University of Pavia, Pavia, Italy, 27100*

<sup>2</sup>*Electromagnetics Laboratory, Department of Physics, University of Malta, Msida, Malta, 2080*

**Keywords: Human, RF/Microwaves, Work in Progress**

**Presented by: Simona Di Meo**

In this abstract, the work still in progress done by the Microwave Laboratory of the University of Pavia is presented. The abstract addresses all the main aspects of the research from the dielectric characterization of human breast ex-vivo tissues (up to 50GHz) to the final test of the mm-wave imaging prototype on realistic breast phantoms. The future work regarding the dielectric characterization of in-vivo samples on a relatively small colony of mice is also presented, along with the current collaboration with the University of Malta mainly intended to assess (and possibly quantify) the statistical difference between the dielectric properties derived from ex-vivo samples taken from animals and taken from human cadavers.

**FB-10 [14:27]**

**STUDENT PAPER**

**Specific absorption rate analysis of a dual-band planar monopole antenna with a metasurface resonator for 5G / WLAN applications**

Min-Joo Jeong<sup>1</sup>, Niamat Hussain<sup>1</sup>, Hanul Bong<sup>1</sup>, Ji Woong Park<sup>1</sup>, Seungwoo Lee<sup>2</sup> & Nam Kim<sup>1</sup>

<sup>1</sup>*College of Electrical and Computer Engineering, Chungbuk National University, Cheongju-si, Korea, 28644*

<sup>2</sup>*Korea Electric Power Research Institute, Daejeon, Korea, 34056*

**Keywords: Human, RF/Microwaves, Work in Progress**

**Presented by: Min-Joo Jeong**

In this paper, we present a dual-band planar monopole antenna using metasurface (MS) resonator with low specific absorption rate (SAR) for 5G and WLAN applications. The proposed antenna is designed by adding an MS resonator to a monopole antenna fed by a co-planar waveguide (CPW). We calculated the SAR for 1 g and 10 g tissue at 0 mm distance of antenna from the head instead of 10 mm, which is stricter than the international standards, and computed the SAR values at 3.5 GHz and 5.8 GHz. The SAR values are found to be 0.823 W/kg for 1 g and 0.584 W/kg for 10 g at 3.5 GHz and 1.3 W/kg for 1 g, and 0.877 W/kg for 10 g at 5.8 GHz, which are under the international safety SAR standards.

**FB-11 [14:30]**

**WITHDRAWN**

**FB-12 [14:33]**

**WITHDRAWN**

**FB-13 [14:36]**

**WITHDRAWN**

**FB-14 [14:39]**

**WITHDRAWN**

**Session: PB**  
**Poster Session B**  
**Tuesday June 25, 2019 • 15:00 - 16:30**  
**Joffre 2-3**

**PB-2 [15:00]**

**Radiofrequency electromagnetic fields exposure, screen time, brain morphology, and attention problems in school-age children**

Mònica Guxens<sup>1, 2</sup>, Alba Cabré<sup>1</sup>, Ryan Muetzel<sup>2</sup>, Luuk van Wel<sup>3</sup>, Ilaria Liorni<sup>4</sup>, Myles Capstick<sup>4</sup>, Roel Vermeulen<sup>3</sup>, Martine Vrijheid<sup>1</sup>, Tonya White<sup>2</sup> & Hanan El-Marroun<sup>2</sup>

<sup>1</sup>*ISGlobal, Barcelona, Spain*

<sup>2</sup>*ErasmusMC, Rotterdam, the Netherlands*

<sup>3</sup>*IRAS, Utrecht University, Utrecht, the Netherlands*

<sup>4</sup>*IT'IS Foundation, Zurich, Switzerland*

**Keywords: Behavioural, Static, Completed (published)**

**Presented by: Monica Guxens**

We investigated the association between radiofrequency electromagnetic fields (RF-EMF) exposure, screen time, and brain morphology in school-age children and to assess whether brain morphology mediated the association between RF-EMF exposure, screen time, and behaviour problems. We found that RF-EMF dose to the brain was not associated with brain morphology alterations. However, longer use of screen devices, in particular television use, was associated with smaller brain volume, and these alterations partially mediated the association between higher television use and higher attention problems.

**PB-4 [15:00]**

**WITHDRAWN**

**PB-6 [15:00]**

**WITHDRAWN**

**PB-8 [15:00]**

**Novel coil design for deep transcranial magnetic stimulation**

Mai Lu<sup>1</sup> & Shoogo Ueno<sup>2</sup>

<sup>1</sup>*Key Lab. of Opt-Electronic Technology and Intelligent Control of Ministry of Education, Lanzhou Jiaotong University, Lanzhou, China, 730070*

<sup>2</sup>*Department of Applied Quantum Physics, Kyushu University, Fukuoka, Japan, 812-8581*

**Keywords: Clinical (therapy), ELF/LF, Work in Progress**

**Presented by: Shoogo Ueno**

New coil designs have been developed by considering both H- and Halo coils. The induced magnetic and electric fields in head tissues were obtained by applying the H-Halo-1 and H-Halo-2 coils, respectively. And the results were compared with that of conventional H-coil. Both the H-Halo-1 and H-Halo-2 coils have significant depth penetration compared to that of the conventional H-coil. The novel coil design in this work offer advantage over the H-coil of simple windings and deeper penetration depth.

**PB-10 [15:00]**

**Numerical calculation of biological tissue coagulated region generated by microwave surgical device**

Kazuyuki Saito<sup>1</sup> & Ryo Manago<sup>1</sup>

<sup>1</sup>*Chiba University, Chiba, Japan, 2638522*

**Keywords: Clinical (therapy), RF/Microwaves, Work in Progress**

**Presented by: Kazuyuki Saito**

In the surgical treatment, the microwave energy increases temperature on surface of the biological tissue such as any organs and generates a coagulated region. Generally, biological tissue coagulates at approximately 60 °C or higher. Therefore, distributions of temperature elevation have been calculated and analyzed. However, when the heating time is long, the biological tissue coagulates even if it is less than 60 °C. Therefore, shape of the coagulated region generated by the surgical device should also be investigated. In this study, shape of the coagulated region by a microwave surgical device is calculated. In addition, validity of the calculation method could be found by comparison with experimental result.

**PB-12 [15:00]**

**Uncertainty quantification of RF exposure for assessment of RF impacts on brain activity**

Xi Cheng<sup>1</sup>, Clement Henry<sup>2</sup>, Francesco Andriulli<sup>2</sup> & Joe Wiart<sup>1</sup>

<sup>1</sup>Chaire C2M, Télécom ParisTech Université Paris-Saclay, Paris, France, 75013

<sup>2</sup>Politecnico di Torino, Turin, Italy

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**

**Presented by: Xi Cheng**

The study of the effects of radio frequency (RF) radiation on brain activity represent an application and research scenario of central and fundamental importance. This paper focuses on quantifying the uncertainty in specific absorption rate (SAR) induced by the uncertainty of the position of the electroencephalographic electrodes. It contributes to the work aimed to perform a high resolution electroencephalography (EEG) measurement to assess the effects of a RF radiation on brain activity without substantially perturbing it. An experimental design is obtained, and the idea of a space-dependent surrogate model which combines principal component analysis (PCA) and Kriging model or polynomial chaos expansion (PCE) is presented.

**PB-14 [15:00]**

**Influence of skin conductivity on the electric field induced in the head by noninvasive brain stimulation techniques**

Micol Colella<sup>1</sup>, Alessandra Paffi<sup>1</sup>, Sara Fontana<sup>1</sup>, Federico Rossano<sup>1</sup>, Valerio De Santis<sup>2</sup>, Francesca Apollonio<sup>1</sup> & Micaela Liberti<sup>1</sup>

<sup>1</sup>Department of Information Engineering, Electronics and Telecommunications (DIET), University of Rome "La Sapienza", Rome, Italy, 00184

<sup>2</sup>Department of Industrial and Information Engineering and Economics (DIIE), University of L'Aquila, L'Aquila, Italy, 67040

**Keywords: Dosimetry (computational), ELF/LF, Work in Progress**

**Presented by: Micol Colella**

Numerical evaluation of the electromagnetic (EM) quantities induced inside the brain during noninvasive brain stimulation techniques is a fundamental step to obtain the optimization of the treatment in terms of position of the stimulator and intensity of the stimulation. In this sense, the electromagnetic properties used to characterize the tissues have an influence on the EM solution. Thus, the aim of this study is to evaluate how different skin conductivities influence the electric field induced inside the brain of the detailed anatomical human head model MIDA by a TMS coil and by tDCS electrodes.

**PB-16 [15:00]**

**A simple and reliable exposure system for seed magneto-priming applications**

Claudio D'Elia<sup>1</sup>, Aniello Crescenzi<sup>3</sup>, Nicola D'Ambrosio<sup>2</sup> & Rita Massa<sup>1</sup>

<sup>1</sup>Department of Physics "Ettore Pancini", Università di Napoli "Federico II", Naples, Italy, 80126

<sup>2</sup>Department of Biology, Università di Napoli "Federico II", Naples, Italy, 80126

<sup>3</sup>SAFE- School of Agricultural, Forest, Food and Environmental Sciences, Università della Basilicata, Potenza, Italy, 85100

**Keywords: Dosimetry (computational), Static, Completed (unpublished)**

**Presented by: Claudio D'Elia**

An exposure system has been designed, realized and characterized on the basis of uniformity criteria and the desired magnetic induction level (50 mT - 320 mT range). It has been configured as a magnetic circuit able to confine induction magnetic field, generated by a couple of permanent magnets, with an high homogeneity field distribution (CV less than 0.02) in a maximum volume of about 3.5 cm<sup>3</sup>. The applicator will be used in the framework of a project which aim is the evaluation of static magnetic induction mechanisms on seeds for enhancing their quality.

**PB-18 [15:00]**

**STUDENT PAPER**

**Three dimensional microdosimetry study at millimeter waves**

Zain Haider<sup>1</sup>, Maxim Zhadobov<sup>1</sup>, Yves Le Dréan<sup>2</sup> & Ronan Sauleau<sup>1</sup>

<sup>1</sup>Univ Rennes, CNRS, IETR – UMR 6164, F-35000 Rennes, France

<sup>2</sup>Univ Rennes, Inserm, EHESP, IRSET (Institut de recherche en santé, environnement et travail) – UMR\_S 1085, F-35000 Rennes, France

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**

**Presented by: Zain Haider**

A microdosimetric study is performed on biological cells models in the 60 GHz band. Complex permittivity data of dielectric models of the membrane, cytoplasm, and extracellular medium at microwaves have been extrapolated to millimeter-wave frequencies. A quasi-static electromagnetic (EM) analysis is employed to solve the Laplace equation both analytically and numerically. Preliminary results provide insight into millimeter-wave power deposition at the sub-cellular level.

**PB-20 [15:00]**

**Development and management of the magnetic field prediction software for overhead and underground transmission lines**

Seungwoo Lee<sup>1</sup>, Jeongill Hwang<sup>2</sup>, Sang-su Noh<sup>2</sup>, Kyungku Nah<sup>2</sup>, Chang-nam Jin<sup>2</sup> & Ho Sung An<sup>1</sup>

<sup>1</sup>Power Transmission Laboratory, KEPRI, Daejeon, Korea, 34056

<sup>2</sup>Transmission and Substation Construction Dept., KEPCO, Naju, Korea, 58217

**Keywords: Dosimetry (computational), ELF/LF, Work in Progress**

**Presented by: Seungwoo Lee**

In this study, the magnetic field prediction software exposed by overhead and unground transmission lines is developed. The software can be reduced by considering the human effects of the magnetic fields exposed by the transmission lines before construction design stages. The software produced very similar values that measured in the actual environment, and it is believed that the magnetic field could be reduced to the desired values by considering the results prior to construction of the transmission line.

**PB-22 [15:00]**

**STUDENT PAPER**

**Characteristics of temperature rise in a human eyeball due to a dipole antenna in frequency range from 6 GHz to 30 GHz**

Shugo Nishikawa<sup>1, 2</sup>, Tomoaki Nagaoka<sup>2</sup>, Soichi Watanabe<sup>2</sup>, Ryosuke Suga<sup>1</sup>, Kanako Wake<sup>2</sup> & Osamu Hashimoto<sup>1</sup>

<sup>1</sup>Graduate School of Science and Engineering, Sagamihara, Japan, 252–5258

<sup>2</sup>National Institute of Information and Communication, Koganei, Japan, 184-8795

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**

**Presented by: Shugo Nishikawa**

Recently, the use of smartphones and tablet terminals for data communication has increased. For 5G, data

communication via mobile terminals is expected to increase more than ever. In a frequency band above 6 GHz, the electromagnetic energy is mainly absorbed on the surface of the human body. Therefore, we focused on the temperature in the eyeball and its surroundings by placing a wireless communication terminal in front of the eyes. In this study, we estimated the temperature rise in the eyeball due to a half-wavelength dipole antenna in a frequency range from 6 GHz to 30 GHz located close to a human eye using an anatomical model with high fidelity and high resolution.

#### **PB-24 [15:00]**

##### **Potential underestimation of exposure when applying simplified body models proposed in product standards IEC 62822-x for welding equipment**

Gernot Schmid<sup>1, 2</sup>, Rene Hirtl<sup>1</sup> & Theodoros Samaras<sup>2</sup>

<sup>1</sup>*EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, A-2444*

<sup>2</sup>*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece, GR-54124*

**Keywords:** *Dosimetry (computational), ELF/LF, Work in Progress*

**Presented by:** *Gernot Schmid*

For assessing magnetic field exposure IEC 62822-x proposes a simplified procedure in which body parts are modelled as homogeneous circular disk models. According to IEC 62822-x this approach can then be used to compute worst case in situ electric field strength  $E_i$  inside body parts at a certain distance to welding equipment. However, we failed to validate the mentioned procedure for the situation of a welding cable along the lower arm and hand, based on numerical computations using four different anatomical body models. The results show that the disk model-based approach may substantially underestimate actual exposure due to the fact that the disks oversimplify anatomical features relevant for the resulting maximum  $E_i$ .

#### **PB-26 [15:00]**

##### **Computer simulations of the penetration of 30 to 90 GHz radiation into the human ear**

Zoltan Vilagosh<sup>1</sup>, Alireza Lajevardipour<sup>1</sup> & Andrew Wood<sup>1</sup>

<sup>1</sup>*Health and Medical Sciences, Swinburne University of Technology, Hawthorn, Australia, 3122*

**Keywords:** *Dosimetry (computational), RF/Microwaves, Completed (unpublished)*

**Presented by:** *Zoltan Vilagosh*

Given the interest in expanding communication to 30-90 GHz frequencies, and the capacity of the outer ear to act as waveguide, the penetration of these frequencies into the ear needs to be explored. Simulations show that at 30 GHz the tympanic membrane is shielded from radiation from all angles with the tympanic membrane experiencing a power density (PD) in the order of 2% of that of the outer skin. At 90 GHz, exposure reaches 10% of the incident PD. Given that the tympanic membrane is richly innervated and well supplied with blood, the thermal and sensory effect of the incident radiation at these frequencies needs to be explored, as the recommendations for exposure of the outer skin may not be adequate.

#### **PB-28 [15:00]**

##### **Evaluation of SAR in adult anatomical model caused by exposure from UHF RFID readers**

Patryk Zradziński<sup>1</sup>, Jolanta Karpowicz<sup>1</sup>, Krzysztof Gryz<sup>1</sup> & Victoria Ramos González<sup>2</sup>

<sup>1</sup>*Laboratory of Electromagnetic Hazards, Central Institute for Labour Protection - National Research Institute, Warszawa, Poland, 00-701*

<sup>2</sup>*Telemedicine and e-Health Research Unit, Carlos III Institute of Health, Madrid, Spain*

**Keywords:** *Dosimetry (computational), RF/Microwaves, Work in Progress*

**Presented by:** *Patryk Zradziński*

The ultra-high frequency radiofrequency identification (UHF RFID) readers are widely used e.g. in shops, libraries, hospitals. The nature of the work of employees of these institutions often requires approaching to such readers and even holding them close to the body and thus exposure to the electromagnetic field. The SAR value is evaluating in human body model present near UHF RFID readers operating at 856 MHz considering various exposure scenarios. The results of ongoing study showed e.g. that SAR values from UHF

RFID readers 5 cm away from the body approach general public exposure limit values, during 6 minute exposure for radiated power higher than 3.3 W.

#### **PB-30 [15:00]**

##### **Features of the second generation of personal EM exposimeter DEVIN**

Serge Bories<sup>1</sup>, David Dassonville<sup>1</sup>, Saifeddine Aloui<sup>1</sup>, Laurent Lombard<sup>1</sup>, Joe Wiart<sup>3</sup> & Isabelle Deltour<sup>2</sup>

<sup>1</sup>CEA LETI Minatec Campus, Grenoble, France

<sup>2</sup>IARC, Lyon, France

<sup>3</sup>C2M, Télécom ParisTech, Paris, France

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Serge Bories*

The population EM exposure and its long-term evolution will be better assessed through daily, in situ measurements, and by embracing the wide diversity of usages, of telecom and wireless standards but also the network infrastructure technological deployment choices. The innovating personal exposimeter DEVIN is simply attached to the user's smartphone in order to log both the effective transmitted RF power and to classify the user activities all along the day. This second generation of exposimeter has been miniaturized. WiFi and new cellular bands have been implemented. Four proximity sensors are used to accurately estimate the source position regarding the user's body. These new features are presented in this paper.

#### **PB-32 [15:00]**

##### **EMF exposure evaluation for manhole type base stations**

Junji Higashiyama<sup>1</sup> & Teruo Onishi<sup>1</sup>

<sup>1</sup>Research Laboratories, NTT DOCOMO, INC., Yokosuka, Kanagawa, Japan, 239-8536

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Junji Higashiyama*

This paper presents the measurement results of radio frequency exposure to manhole-type base stations installed underground using the measurement methods standardized in IEC 62232: 2017, in order to evaluate exposure to these base stations and obtain some reference data to consider suitable computation methods for exposure evaluations for such the base stations installed underground.

#### **PB-34 [15:00]**

##### **STUDENT PAPER**

##### **Measurement campaign for the assessment of electromagnetic fields near cellular base stations in Belgium**

Rachel Nkem Iyare<sup>1</sup>, Vladimir Volskiy<sup>1</sup> & Guy A.E Vandenbosch<sup>1</sup>

<sup>1</sup>Electrical Engineering, Katholieke Universiteit, Leuven, Belgium, 3001

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Completed (unpublished)*

**Presented by:** *Rachel Nkem Iyare*

The electromagnetic radiation emitted by cellular base stations in Belgium is measured. The objective of this assessment is to provide the relevant information on electromagnetic fields produced by cellular base stations and to investigate the changes of electromagnetic exposure within a typical day and over multiple days in the vicinity of these base stations. The measurements were performed using highly precise measurement equipment in public areas comprising different locations. The exposure was carried out for mobile communication networks. The results show that all analyzed locations are in compliance with the exposure limits recommended by ICNIRP and that the exposure levels are reproducible over a time span of ca. one month.

#### **PB-36 [15:00]**

##### **A study on power density measurement method for 5G mobile phone**

Kihwea Kim<sup>1</sup> & Dong Geun Choi<sup>1</sup>

<sup>1</sup>EMF, National Radio Research Agency, Naju, Korea, 58323

**Keywords: Dosimetry (measurements), RF/Microwaves, Completed (published)**

**Presented by: Kihwea Kim**

A measurement method of the power density (28 GHz) in near-field region was proposed to verify the compliance of the 5G mobile phone with the electromagnetic wave human protection standards. We were verified through simulation and measurement considering the beamforming technology, the measurement technology of the electromagnetic wave in high frequency, the setting of the minimum separation distance for the evaluation, use of reconstruction algorithm method, etc. Based on this, the world's first power density measurement method of 5G mobile phone was proposed.

#### **PB-38 [15:00]**

##### **CDMA, WCDMA and LTE networks and transmitted power of mobile phones**

Ae-kyoung Lee<sup>1</sup> & Hyung-Do Choi<sup>1</sup>

<sup>1</sup>Radio Technology Research Department, Electronics and Telecommunications Research Institute (ETRI), Daejeon, Korea

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Ae-kyoung Lee**

In 2015 and 2017, the transmitted power data of mobile phones during a voice call had been collected in operating CDMA 2000, WCDMA, and LTE networks in Seoul, Korea to utilize the results in epidemiological studies [1], [2]. The objective of this abstract is to present the change in the frequency bands of LTE as well as the Tx power level between the two different time windows. As a result, the Tx power has mostly decreased in 2017 compared to that in 2015. However, connection proportions between LTE bands have greatly varied and significant differences between operators were observed.

#### **PB-40 [15:00]**

##### **Broadband and band-selective measurements of radiofrequency EM field with drone system – A feasibility study**

Peter Necz<sup>1</sup>, Balázs Gyulai<sup>2</sup>, József Krausz<sup>2</sup> & György Thuroczy<sup>1</sup>

<sup>1</sup>Department of Non-Ionizing Radiations, National Public Health Center, Budapest, Hungary, 1221

<sup>2</sup>National Media and Infocommunications Authority, Budapest, Hungary, 1015

**Keywords: Dosimetry (measurements), RF/Microwaves, Work in Progress**

**Presented by: Peter Necz**

The aim of present study was to check the feasibility of a method to measure the RF field and exposure patterns of fixed outdoor RF sources at locations difficult to access by drone system. Other aim was to check how to use common RF survey broadband meter (Narda NBM-550) and lightweight personal exposimeter (ExpoM-RF) in the study. We found that the synchronization of both position and data logging are the most important parameters in the RF exposimetry by drones. Conducting measurements by common, commercially available exposimeters should be useful in the future exposimetry studies, nevertheless several conditions must be considered in the planning phase and carrying out such studies.

#### **PB-42 [15:00]**

##### **STUDENT PAPER**

##### **Dosimetric study of electrophysiological recording devices based on micro-electrodes under Radio-Frequency exposures**

Amani Nefzi<sup>1</sup>, Clement E. Lemerrier<sup>2</sup>, Noëlle Lewis<sup>2</sup>, Isabelle Lagroye<sup>2, 3</sup>, Philippe Leveque<sup>1</sup> & Delia Arnaud-Cormos<sup>1</sup>

<sup>1</sup>Univ. Limoges, CNRS, XLIM, UMR 7252, Limoges, France, 87000

<sup>2</sup>Univ. Bordeaux I, CNRS, IMS, UMR 5218, Talence, France, 33400

<sup>3</sup>Paris “Sciences et Lettres” Research University, EPHE, Paris, France

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Work in Progress*

**Presented by:** *Amani Nefzi*

In this work, recording devices based on micro-electrodes were developed to study the electrical activity of neurons while exposed to RF fields. The exposure system used for RF application is a Transverse Electromagnetic (TEM) cell. An RF exposure setup is described, the results of the experimental dosimetry of the two micro-electrodes recording devices are explored. Experimental dosimetry proved that TEM cell containing the micro-electrodes devices has a good energy transfer with a return loss under -10 dB the frequency band up to 3 GHz. Applying 5 W for 30 minutes to 1 mL of biological medium within the micro-electrode device induced a temperature elevation of around 1.5°C.

#### **PB-44 [15:00]**

##### **Thermal convection in *in vitro* samples exposed to millimeter waves in continuous and pulse-modulated regimes**

Rosa Orlacchio<sup>1</sup>, Maxim Zhadobov<sup>1</sup>, Stanislav Alekseev<sup>2</sup>, Denys Nikolayev<sup>3</sup>, Ronan Sauleau<sup>1</sup>, Yann Le Page<sup>4</sup>, Denis Habauzit<sup>4</sup> & Yves Le Dréan<sup>4</sup>

<sup>1</sup>Univ Rennes, CNRS, IETR – UMR 6164, F-35000, Rennes, France

<sup>2</sup>Institute of Cell Biophysics of Russian Academy of Sciences, Pushchino, Russian Federation

<sup>3</sup>Microwaves and Antennas Group (MAG), EPFL, CH-1015, Lausanne, Switzerland

<sup>4</sup>Univ Rennes, Inserm, EHESP, IRSET (Institut de recherche en santé, environnement et travail) – UMR\_S 1085, F-35000, Rennes, France

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Completed (unpublished)*

**Presented by:** *Rosa Orlacchio*

This study investigates the impact of convection on temperature dynamics in a typical *in vitro* exposure scenario during continuous and pulsed millimetre-wave (MMW) induced heating. Results showed that the onset of convection during continuous heating i) is preceded by the appearance of a temperature peak, which occurrence in time depends on SAR (the higher the SAR, the earlier the convection is triggered), ii) depends on the liquid volume (larger volumes result in earlier triggering of convection and greater cooling effect), and iii) depends on the viscosity of the medium. For the pulsed-induced heating results showed that long pulses facilitate the occurrence of convection, which in turn impacts the heat pulse amplitude and cooling rate.

#### **PB-46 [15:00]**

##### **Characterisation of personal exposure to environmental radiofrequency electromagnetic fields in Albacete (Spain) and assessment of risk perception**

Raquel Ramírez-Vazquez<sup>2</sup>, Jesus Gonzalez-Rubio<sup>1</sup>, Enrique Arribas<sup>2</sup> & Alberto Nájera<sup>1</sup>

<sup>1</sup>Medical Sciences, University of Castilla-La Mancha, Albacete, Albacete, Spain, 02009

<sup>2</sup>Applied Physics, University of Castilla-La Mancha, Albacete, Albacete, Spain, 02008

**Keywords:** *Dosimetry (measurements), RF/Microwaves, Completed (published)*

**Presented by:** *Alberto Nájera*

RF-EMF exposure was measured in Albacete (Spain) using personal exposimeters. A description of personal exposure is provided in temporary and spatial terms. Levels of personal exposure were extremely low compared to regulatory limits. Volunteers were informed about the results. Access to the results could help reduce the population's risk perception. Paper is available at: <https://doi.org/10.1016/j.envres.2019.02.015>

#### **PB-48 [15:00]**

##### **Characterization of magnetic fields from an EAS system used in libraries**

Masao Taki<sup>1, 3</sup>, Miwa Ikuyo<sup>1</sup>, Kaoru Esaki<sup>1</sup>, Atsuko Aimoto<sup>1</sup>, Noriko Kojimahara<sup>2</sup>, Kanako Wake<sup>3</sup> & Kenichi Yamazaki<sup>4</sup>

<sup>1</sup>Electrical Engineering and Computer Science, Tokyo Metropolitan University, Hachioji, Tokyo, Japan,

192-0397

<sup>2</sup>Department of Public Health, Tokyo Women's Medical University, Tokyo, Japan, 162-8666

<sup>3</sup>Electromagnetic Compatibility Laboratory, National Institute of Information and Communications Technology, Koganei, Tokyo, Japan, 184-8795

<sup>4</sup>Surge & electromagnetic phenomena, Central Research Institute of Electric Power Industry (CRIEPI), Yokosuka, Japan, 240-0196

**Keywords: Dosimetry (measurements), IF, Work in Progress**

**Presented by: Masao Taki**

Magnetic field distribution was measured in consideration of the phase of each vector component for the gate of an electronic article surveillance system used in a library. The magnetic field was found elliptically polarized with different ellipticity depending on the location in the gate. Distribution of the ellipticity was examined for incident magnetic field. The induced electric field was also calculated numerically by impedance method assuming a human model passing through the gate.

**PB-50 [15:00]**

**WITHDRAWN**

**PB-52 [15:00]**

**WITHDRAWN**

**PB-54 [15:00]**

**Is an electrostatic field able to induce a galvanotactic phenomenon? Investigation in a scrape wound model**

Isabella Zironi<sup>1</sup>, Gabriele D'Amen<sup>2</sup>, Annalisa De Angelis<sup>3</sup>, Laura Caramazza<sup>3</sup>, Alessandro Gabrielli<sup>2</sup> & Gastone Castellani<sup>1, 2</sup>

<sup>1</sup>Physics and Astronomy Department, University of Bologna, Bologna, Italy, 40126

<sup>2</sup>National Institute for Nuclear Physics (INFN), Bologna, Italy, 40126

<sup>3</sup>ICEmB at Department of Information Engineering, Electronics and Telecommunications, University of Rome Sapienza, ROMA, Italy, 00184

**Keywords: Electrochemistry, Static, Work in Progress**

**Presented by: Annalisa De Angelis**

Galvanotaxis is a bioelectronic phenomenon representing the movement of a living organism in response to an electric stimulus. The majority of the experiments in the galvanotaxis area are conducted under the action of a d.c. field, and involve metal electrodes directly inserted into the medium containing the cells. In the present work, we investigated the alterations in cell migratory capacity in response to a "non contact" EF application by an in vitro scrape wound assay and a prediction of the dose at the cell level by numerical modelling.

**PB-56 [15:00]**

**Numerical investigations on the action of CW electric fields on lipid vesicles for drug delivery**

Laura Caramazza<sup>1, 2</sup>, Annalisa De Angelis<sup>1</sup>, Elena della Valle<sup>3</sup>, Agnese Denzi<sup>1</sup>, Martina Nardoni<sup>4</sup>, Patrizia Paolicelli<sup>4</sup>, Stefania Petralito<sup>4</sup>, Francesca Apollonio<sup>1</sup> & Micaela Liberti<sup>1</sup>

<sup>1</sup>ICEmB@DIET, Sapienza University of Rome, Rome, Italy, 00184

<sup>2</sup>Center for Life Nano Science@Sapienza, Istituto Italiano di Tecnologia, Rome, Italy, 00161

<sup>3</sup>Bioelectronic Vision Lab, Biomedical Engineering Department, University of Michigan, Ann Arbor, Michigan State, USA, 2800

<sup>4</sup>Department of Drug Chemistry and Technology, Sapienza University of Rome, Rome, Italy, 00185

**Keywords: Electroporation, RF/Microwaves, Work in Progress**

**Presented by: Laura Caramazza**

The electromagnetic (EM) fields application together with the use of biocompatible drugs nanocarriers has been recently studied to enhance medical treatments. In this context, liposomes, biocompatible lipid vesicles, are recently under investigation both as EM fields triggerable carriers and as simple model mimicking cell membrane response. In this work, 2D microdosimetric analyses on single liposomes, with a range dimension from the nano to the micro-meter scale, have been performed studying the feasibility to increase biological membrane permeability through radiofrequency fields. Lastly, the response of a 2D model of 142 randomly placed nanosized liposomes has been proposed as a more realistic drug delivery systems suspension.

**PB-58 [15:00]  
STUDENT PAPER**

**Microsecond kinetics of ion transport and interface binding in electrically stressed phospholipid bilayers**

Federica Castellani<sup>1, 2</sup>, Esin B Sözer<sup>1</sup> & P. Thomas Vernier<sup>1</sup>

<sup>1</sup>*Frank Reidy Research Center for Bioelectrics, Norfolk, Va, USA, 23508*

<sup>2</sup>*Biomedical Engineering, Frank Batten College of Engineering and Technology, Norfolk, Va, USA, 23508*

**Keywords: Electroporation, Pulsed, Work in Progress**

**Presented by: Federica Castellani**

Formation of bilayer-spanning water bridges and conductive lipid pores is enhanced by the application of transmembrane electric fields. Drugs, nucleic acids, and other normally impermeant material can enter cells through these lipid electropores. The mechanisms underlying this process, called electroporation or electropermeabilization, are not well understood. Molecular dynamics simulations of lipid membranes in electric fields can be used to investigate this phenomenon at the experimentally inaccessible nanoscale. Here we describe the previously unexplored microsecond kinetics of ion binding to phospholipid bilayers and transport through lipid electropores in double bilayer systems containing K<sup>+</sup>, Ca<sup>2+</sup>, and Cl<sup>-</sup>.

**PB-60 [15:00]  
STUDENT PAPER**

**Development of estimation model for exposure of magnetic field at intermediate frequency from household induction cooker**

Takumi Kitajima<sup>1</sup>, Akemi Morita<sup>1</sup>, Wakaha Ikeda<sup>2</sup>, Mukaide Takahiro<sup>1</sup>, Yoshikazu Matsuda<sup>1</sup>, Amexo Jennifer<sup>1</sup>, Kuurdor Deku-Mwin<sup>1</sup>, Thida Win<sup>1</sup>, Masao Taki<sup>3</sup> & Shigeru Sokejima<sup>1, 2</sup>

<sup>1</sup>*Department of Public Health and Occupational Medicine, Tsu City, Japan, 514-8507*

<sup>2</sup>*Epidemiology Centre for Disease Control and Prevention, Mie University Hospital, Tsu City, Japan, 514-0001*

<sup>3</sup>*Department of Electrical and Electronic Engineering, Hachioji City, Japan, 192-0397*

**Keywords: Epidemiology, IF, Work in Progress**

**Presented by: Takumi Kitajima**

Epidemiological studies have not yet been conducted to investigate health effects due to exposure of electromagnetic fields at the intermediate frequency (IF) band. As a first step this study, we tried to develop an IF exposure estimation model from Induction cooker in the home environment. As a result, it was found that the distance relation from the hob, diameter of cooking pan, heat power wattage, width of heater housing greatly contributed. Also, the current model tends to lose accuracy as the estimate of high value becomes higher. The future task is to examine question sentences to accurately answer the positional relationship with the body surface.

**PB-62 [15:00]**

**Exposure to intermediate-frequency electromagnetic fields generated by induction cookers**

Akemi Morita<sup>1</sup>, Takumi Kitajima<sup>1</sup>, Wakaha Ikeda<sup>2</sup>, Mukaide Takahiro<sup>1</sup>, Yoshikazu Matsuda<sup>1</sup>, Amexo Jennifer<sup>1</sup>, Kuurdor Deku-Mwin<sup>1</sup>, Thida Win<sup>1</sup>, Masao Taki<sup>3</sup> & Shigeru Sokejima<sup>1, 2</sup>

<sup>1</sup>*Department of Public Health and Occupational Medicine, Mie University, Tsu, Japan, 5148507*

<sup>2</sup>*Epidemiology Centre for Disease Control and Prevention, Mie University Hospital, Tsu, Japan, 5148507*

<sup>3</sup>Department of Electrical and Electronic Engineering, Tokyo Metropolitan University, Hachioji, Japan, 1920397

**Keywords: Epidemiology, IF, Work in Progress**

**Presented by: Akemi Morita**

Intermediate-frequency (IF) electromagnetic fields (EMF) are generated by induction-heating (IH) cookers and a variety of industrial facilities. Unfortunately, research for the potential health effects associated with exposure to IF-EMF are lacking. We investigated usage of IF-EMF emitting appliances and exposure level from IH cookers in the household. We conducted a web survey of usage of IF emitting appliances for Japanese women aged 20-54 in Mie prefecture and measured the exposure level from the IH cookers in 50 households. Thirty three % of the respondents had IH cooker in their home. Average maximum magnetic flux density exposed by IH cookers is 4 micro T. The exposure level from IH cookers was suggested to be limited.

#### **PB-64 [15:00]**

##### **Prenatal and postnatal mobile phone use and cognitive functions in 5-year-old children**

Heesun Yang<sup>1</sup>, Hyunjoo Joo<sup>1</sup>, Xue Han<sup>2</sup>, Yong-Han Lee<sup>2</sup>, Eun-Hee Ha<sup>3</sup>, Hyesook Park<sup>4</sup>, Yangho Kim<sup>5</sup>, Yun-Chul Hong<sup>6</sup>, Nam Kim<sup>7</sup>, Jong Hwa Kwon<sup>8</sup>, Hyung-Do Choi<sup>8</sup>, Ae-kyoung Lee<sup>8</sup>, Kyung-Hwa Choi<sup>2</sup>, Sanghyuk Bae<sup>9</sup>, Mina Ha<sup>2</sup> & Ho-Jang Kwon<sup>2</sup>

<sup>1</sup>Department of Public Health, Dankook University, Choeran, Korea, 31116

<sup>2</sup>Department of Occupational and Environmental Medicine, Ewha Womans University, S, Korea, 31116

<sup>3</sup>Department of Occupational and Environmental Medicine, Ewha Womans University, Seoul, Korea, 07804

<sup>4</sup>Department of Preventive Medicine, Ewha Womans University, Seoul, Korea, 07804

<sup>5</sup>Department of Occupational and Environmental Medicine, Ulsan University Hospital, University of Ulsan, Ulsan, Korea, 44033

<sup>6</sup>Department of Preventive Medicine, Seoul National University, Seoul, Korea, 03087

<sup>7</sup>School of Information and Communication Engineering, Cheongju, Korea, 28644

<sup>8</sup>Broadcasting and Media Research Laboratory, Electronics and Telecommunications Research Institute, Daejeon, Korea, 34129

<sup>9</sup>Department of Preventive Medicine, Catholic University, Seoul, Korea, 06591

**Keywords: Epidemiology, RF/Microwaves, Work in Progress**

**Presented by: Kyung-Hwa Choi**

This study examined the relationship between pre- and postnatal mobile phone use and the cognitive scores of 5-year-old children. The IQ of the 5-year-old child was lower by -6.91 in the group with heavy users ( $\geq 6$  / day) in both pre- and postnatal mobile phone use compared to the group with light users ( $< 6$  / day) in both pre- and postnatal mobile phone use, but it was not significant (p value = 0.15). We found no evidence for a significant association between prenatal and postnatal mobile phone use and children's cognitive development in 5-year-old children.

#### **PB-66 [15:00]**

##### **24-hour monitoring of nsPEF-induced morphological changes, in U-87 MG cells, using digital holographic microscopy**

Lynn Carr<sup>1, 2</sup>, Cristiano Palego<sup>2</sup>, Yann Percherancier<sup>3, 4</sup>, Delia Arnaud-Cormos<sup>1</sup> & Philippe Leveque<sup>1</sup>

<sup>1</sup>Univ. Limoges, CNRS, XLIM, UMR 7252, Limoges, France, F-87000

<sup>2</sup>School of Electrical Engineering, Bangor University, Bangor, United Kingdom

<sup>3</sup>Laboratoire de l'Intégration du Matériau au Système, Centre National de la Recherche Scientifique (CNRS) UMR 5218, Talence, France

<sup>4</sup>Université de Bordeaux, Talence, France

**Keywords: In vitro, Pulsed, Work in Progress**

**Presented by: Lynn Carr**

Digital holographic microscopy is a technique that allows real-time visualisation of cellular morphology. We

used the M4 Holomonitor, which is adapted for use in an incubator, to monitor changes in U-87 MG cells over a 24 hour time period following exposure to nanosecond pulsed electric fields (nsPEF). Pulse exposure was shown to cause a reduction in cell-cell interactions and to induce cellular rounding.

#### **PB-68 [15:00]**

##### **RF signaling by cancer cells and bacteria?**

Frank Barnes<sup>1</sup>, Sahithi Kandala<sup>1</sup> & Mark Hernandez<sup>2</sup>

<sup>1</sup>*Electrical, Computer and Energy Engineering, University of Colorado Boulder, Boulder, CO, USA, 80309*

<sup>2</sup>*Environmental Engineering, University of Colorado Boulder, Boulder, CO, USA, 80309*

**Keywords: Behavioural, All Frequencies, Completed (published)**

**Presented by: Frank Barnes**

This paper discusses about the possible electromagnetic communication between fibrosarcoma and bacillus subtilis cells in the radio frequency range and lower.

#### **PB-70 [15:00]**

##### **Iron/Sulphur complexes as regulators of redox balance and effects of combined EMF and static fields on ROS production**

Hakki Gurhan<sup>1</sup> & Frank Barnes<sup>1</sup>

<sup>1</sup>*Electrical, Computer and Energy Engineering, Boulder, Colorado, USA, 80309*

**Keywords: In vitro, RF/Microwaves, Work in Progress**

**Presented by: Frank Barnes**

In this study, we're exposing HT-1080 Human fibrosarcoma cells with both EMF and Static Fields. We're using AC electromagnetic waves in the region between 0.1 MHz and 10 MHz since hyperfine coupling for different Iron/Sulphur Complexes occur in this range. Due to their electric and magnetic properties, Iron/Sulphur proteins may affect production of Reactive Oxygen Species (ROS) with the existence of external fields. These proteins are located in membrane bound complexes which are thought to be the major sites of ROS production.

#### **PB-72 [15:00]**

##### **High frequency electromagnetic fields and diesel exhaust nanoparticles co-exposures effects on *in vitro* blood-brain barrier permeability and drug efflux transporter activity**

Samir Dekali<sup>1</sup>, Alexandre Boyard<sup>1</sup>, Flavia Del Vecchio<sup>1</sup> & David Crouzier<sup>1</sup>

<sup>1</sup>*Department of Biological Radiation Effects / Unit of Emerging Technological Risks, French Armed Forces Biomedical Research Institute (IRBA), Brétigny-sur-Orge, France, 91223*

**Keywords: In vitro, RF/Microwaves, Work in Progress**

**Presented by: Samir Dekali**

The aim of the study was to investigate combined effects of diesel exhaust nanoparticles (DEP) and electromagnetic fields (EMF, 100 MHz, modulated square shaped signal at 100 kHz, duty cycle of 10%, power density 100W/m<sup>2</sup>, SAR 0.14W/kg calculated by numerical simulation) at non thermal level on permeability and drug efflux transporter activity of a blood-brain barrier *in vitro* model (BBB). Co-cultures of brain microvascular endothelial cells and microglial cells were exposed in bicameral chambers to DEP in apical compartment with or without EMF during 24h. Results showed significant increase of BBB permeability in case of EMF / DEP co-exposures, while functional P-glycoprotein (P-gp) activity is mainly decreased by DEP exposure.

#### **PB-74 [15:00]**

##### **STUDENT PAPER**

##### **Biohacking *in vitro* wound healing models with electrotherapy**

Jerome Hunckler<sup>1</sup>, Lucien Bartram<sup>3</sup>, Janice Tsui<sup>1</sup> & Brian Cousins<sup>2</sup>

<sup>1</sup>University College London, London, United Kingdom, NW3 2PS

<sup>2</sup>Department of Chemistry, Loughborough University, Loughborough, United Kingdom, LE11 3TU

<sup>3</sup>Globe Microsystems Ltd, Esher, United Kingdom, KT10 8BL

**Keywords:** *In vitro*, Static, Work in Progress

**Presented by:** Jerome Hunckler

Wounded skin possesses a specific pattern of electrical activity called current of injury that is essential to healing. Applying electrical stimulation on chronic wounds may mimic the natural current of injury and enhance regeneration. The overall aim of this study is to set up a model of a cutaneous injury *in vitro*, optimize the electrical stimulation parameters on this model using human dermal fibroblasts, and investigate the behaviour of cells derived from patient with specific diseases under optimised direct current, pulsed current and Naturepulse ® clinical device (Globe Microsystems Ltd, UK).

#### **PB-76 [15:00]**

##### **Effects of reactive oxygen species induced by 405 nm light irradiation on HeLa S3 cells**

Toshitaka Ikehara<sup>1, 2</sup>, Mutsumi Nakahashi<sup>3</sup>, Takahiro Emoto<sup>4</sup>, Masatake Akutagawa<sup>4</sup>, Koichiro Tsuchiya<sup>5</sup>, Akira Takahashi<sup>5</sup> & Yohsuke Kinouchi<sup>4</sup>

<sup>1</sup>Department of Human Welfare, Tokushima bunri University, Tokushima, Japan, 770-8514

<sup>2</sup>Institute for Health Sciences, Tokushima, Japan, 770-8514

<sup>3</sup>Production Environment, Tokushima Agriculture, Forestry, and Fisheries Technology Support Center, Tokushima, Japan, 779-3233

<sup>4</sup>Institute of Science and Technology, Tokushima university, Tokushima, Japan, 770-8506

<sup>5</sup>Institute of Biomedical Sciences, Tokushima University, Tokushima, Japan, 770-8504

**Keywords:** *In vitro*, RF/Microwaves, Work in Progress

**Presented by:** Toshitaka Ikehara

We tested effects of 405 nm light irradiation on HeLa cells. The irradiation for at least 3 hr did not affect the cell viability, but ROS (reactive oxygen species) induced in cells was increased rapidly by the irradiation. This ROS measured by a fluorescent probe was mainly singlet oxygen. A decrease in intracellular glutathione by 1-chloro-2,4-dinitrobenzene strongly increased the intracellular ROS. These results suggest that the intracellular GSH plays as a physiological scavenger of intracellular ROS induced by the light irradiation.

#### **PB-78 [15:00]**

##### **Combined exposure to ultraviolet and radiofrequency radiation of reconstructed human skin model *in vitro* (SKIN-RF project)**

Zsuzsanna Nemeth<sup>1</sup>, Györgyi Kubinyi<sup>1</sup>, Jozsef Bakos<sup>1</sup>, Zsófia Szilágyi<sup>1</sup>, Brahim Selmaoui<sup>2</sup> & György Thuroczy<sup>1</sup>

<sup>1</sup>Department of Non-Ionizing Radiation, National Public Health Center, Budapest, Hungary, 1221

<sup>2</sup>Unité de Toxicologie Expérimentale, L'Institut National de l'Environnement Industriel et des Risques (INERIS), Verneuil en Halate, France, 60550

**Keywords:** *In vitro*, RF/Microwaves, Work in Progress

**Presented by:** Zsofia Szilagyj

The aim of this study was to examine whether the combined exposure to solar ultraviolet (UV) radiation and radiofrequency (RF) exposure have any effect on cytokine (IL-1 $\alpha$ , IL-6, IL-8) and MMP-1 enzyme secretion on *in vitro* reconstructed human skin model. The full thickness skin models were exposed to UV radiation (2 SED, 4 SED) and radiofrequency (Wi-Fi, UMTS). The IL-1 $\alpha$ , IL-6, IL-8 and MMP-1 concentrations were measured 24 hours after UV and RF exposures from the culture media by the ELISA method. This experiment was done for the project named "Cellular response to co-exposure of radiofrequency (RF) and solar ultraviolet (UV) radiation in human *in vitro* skin model (SKIN-RF)".

## **PB-80 [15:00]**

### **Prediction of the tumor promoting potential of ultrahigh and intermediate frequency electromagnetic waves using the Bhas 42 cell transformation assay**

Kiyomi Ohmori<sup>1</sup>, Toru Fukumitsu<sup>1</sup>, Iwaki Nishi<sup>1</sup>, Ken Tachibana<sup>2</sup>, Ken Takeda<sup>2</sup>, Shin Koyama<sup>3</sup>, Eijiro Narita<sup>3</sup>, Junji Miyakoshi<sup>3</sup> & Naoki Shinohara<sup>3</sup>

<sup>1</sup>*Kanagawa Prefectural Institute of Public Health, 1-3-1 Chigasaki, Kanagawa, Japan, 2530087*

<sup>2</sup>*Sanyo-Onoda City University, 1-1-1 Daigaku-dori, Sanyo-Onoda, Yamaguchi, Japan, 7560884*

<sup>3</sup>*Kyoto University, Gokasho, Uji, Kyoto, Japan, 7560884*

**Keywords:** *In vitro, RF/Microwaves, Completed (unpublished)*

**Presented by:** *Kiyomi Ohmori*

The Bhas 42 cell transformation assay (Bhas 42 CTA) was recognized by the Organization for Economic Cooperation and Development (OECD) guidance document as a cell transformation assay in 2016, and became the first internationally recognized in vitro assay that was able to predict tumor promoting potential, including non-genotoxic carcinogenicity. We attempted to predict the tumor promoting potential of ultrahigh and intermediate frequency electromagnetic waves using Bhas 42 CTA. Furthermore, we analyzed the mechanisms of the effects of electromagnetic waves on Bhas 42 cells using molecular biological approaches.

## **PB-82 [15:00]**

### **The effect of a long-term evolution (LTE) on the intracellular calcium concentration**

Tomonori Sakurai<sup>1</sup>

<sup>1</sup>*Department of Radiological Technology, Gifu University of Medical Science, Seki, Japan, 501-3892*

**Keywords:** *In vitro, RF/Microwaves, Completed (unpublished)*

**Presented by:** *Tomonori Sakurai*

In this study, we evaluated the effects of a long-term evolution (LTE) exposure on the intracellular calcium concentration in mammalian cells. We investigated 11 conditions of LTE exposure operated at 1.95 GHz with IMR-32 and NG108-15 cells, which were reported to be affected by exposure to the electromagnetic fields in Blackman's researches. In all the experimental conditions, we could not detect the effects of LTE exposure on intracellular calcium concentration in the cell lines; although the treatment with H<sub>2</sub>O<sub>2</sub> resulted in an increase in intracellular calcium concentration.

## **PB-84 [15:00]**

### **Electrostimulation of adrenal chromaffin cells by 2 ns electric pulses can be modulated by an electric field reversal**

Josette Zaklit<sup>1</sup>, Gale Craviso<sup>2</sup>, Normand Leblanc<sup>2</sup>, P. Thomas Vernier<sup>3</sup> & Esin B Sözer<sup>3</sup>

<sup>1</sup>*Department of Electrical and Biomedical Engineering, University of Nevada Reno, Reno, NV, USA, 89557*

<sup>2</sup>*Department of Pharmacology, University of Nevada Reno, Reno, NV, USA, 89557*

<sup>3</sup>*Frank Reidy Research Center for Bioelectrics, Old Dominion University, Norfolk, VA, USA, 23508*

**Keywords:** *In vitro, Static, Work in Progress*

**Presented by:** *Thomas Vernier*

Bipolar pulse cancellation refers to the suppression of the effect of a unipolar pulse by a following second unipolar pulse of opposite polarity. The purpose of this study is to investigate the effect of 2 ns, 16 MV/m electric pulses on chromaffin cells and to assess whether bipolar pulse cancellation occurs in this neurosecretory cell model. We show that a transient rise in [Ca<sup>2+</sup>]<sub>i</sub> caused by a 2 ns unipolar pulse can be totally eliminated by an immediately following pulse of the same duration and opposite polarity. This cancellation disappears as the interphase interval is increased beyond 30 ns. These results are the first observations that the bipolar pulse cancellation is modulated with interphase intervals of tens of nanoseconds.

**PB-86 [15:00]**

**Gender and age differences in the suppressive effect of a 50 Hz electric field on the immobilization-induced increase of plasma glucocorticoid in mice**

Takuya Hori<sup>1, 2</sup>, Takaki Nedachi<sup>2</sup>, Hiroshi Suzuki<sup>1</sup> & Shinji Harakawa<sup>1, 2</sup>

<sup>1</sup>*Bio-Self-Regulating Science Laboratory, Obihiro, Japan, 080-8555*

<sup>2</sup>*Research and Development Department, Hakuju Institute for Health Science, Tokyo, Japan, 151-0063*

**Keywords:** *In vivo, ELF/LF, Completed (unpublished)*

**Presented by:** *Takuya Hori*

We recently reported the suppression of an immobilization-induced increase in glucocorticoid (GC) levels in mice upon exposure to a 50 Hz electric field (EF) in a strength-dependent manner. The present study extends this research by assessing differences in the effects of EFs by age and gender. We compared the GC levels among control, EF-alone, immobilization-alone, and co-treatment groups. Plasma GC levels were similar in EF-alone and control groups regardless of gender or age. However, the immobilization-induced increase in the GC levels was suppressed by EF application in the male, intact female, and ovariectomized female mice. Furthermore, in all age groups, the immobilization-induced increase in the GC level was suppressed by the EF.

**PB-88 [15:00]**

**Protective effects of RF with different signal modulations in cultured human lymphocytes treated with chemicals**

Stefania Romeo<sup>1</sup>, Anna Sannino<sup>1</sup>, Olga Zeni<sup>1</sup>, Rita Massa<sup>1, 2</sup> & Maria Rosaria Scarfi<sup>1</sup>

<sup>1</sup>*Institute for Electromagnetic Sensing of the Environment (IREA), CNR, Naples, Italy*

<sup>2</sup>*Dept. of Physics "Ettore Pancini", University of Naples "Federico II", Naples, Italy*

**Keywords:** *In vitro, RF/Microwaves, Work in Progress*

**Presented by:** *Rita Massa*

The present paper reports about the induction of protective effects from chemically induced DNA damage, in cultured human lymphocytes pre-exposed to RF electromagnetic fields at 1950 MHz under continuous wave and modulated signals. The results suggest that protective effect of RF takes place in presence of modulated signals and depends on both the bandwidth and applied SAR. Keywords—Radiofrequency, adaptive response, in vitro, modulation, DNA damage

**PB-90 [15:00]**

**Exposures of *Phaseolus vulgaris* L. sprouts to 2.45 GHz induce changes in photosynthesis of adult plants.**

Nicola D'Ambrosio<sup>1, 3</sup> & Rita Massa<sup>2, 3</sup>

<sup>1</sup>*Department of Biology, University of Naples Federico II, Naples, Italy*

<sup>2</sup>*Department of Physics "Ettore Pancini", University of Naples Federico II, Naples, Italy*

<sup>3</sup>*ICEmB, Research Center on Interactions between Electromagnetic Fields & Biosystems, Genoa, Italy*

**Keywords:** *In vivo, RF/Microwaves, Completed (published)*

**Presented by:** *Rita Massa*

Sprouts of *Phaseolus vulgaris* L. were exposed for 24 hours to 2.45 GHz at a 40mW/g SAR level. The controlled dosimetric conditions allowed to determine the thermal increase induced by exposure. After the sprouts were put in pots to obtain adult plants. On fully expanded leaves the photosynthesis was assessed and compared to that of leaves from plants whose sprouts had undergone only temperature increase by conventional heating (like the shoots exposed), and from control plants. In this way we differentiated the thermal and non-thermal effects induced by 2.45 GHz exposure. The initial leaves of plants from sprouts exposed showed a higher photosynthesis, not decreasing during the observation period, unlike the other experimental conditions.

## **PB-92 [15:00]**

### **Alteration of hippocampal gene expression profiles by RF-EMFs**

Ye Ji Jeong<sup>1</sup>, Hyung-Do Choi<sup>2</sup>, Jeong-Ki Pack<sup>3</sup>, Nam Kim<sup>4</sup> & Hae-June Lee<sup>1</sup>

<sup>1</sup>*Division of Basic Radiation Bioscience, Korea Institute of Radiological and Medical Sciences, Seoul, Korea, 01812*

<sup>2</sup>*Department of EMF Research Team, ETRI, Daejeon, Korea*

<sup>3</sup>*College of Engineering, Chungnam National University, Daejeon, Korea*

<sup>4</sup>*School of Electrical and Computer Engineering, Chungbuk National University, Cheongju, Korea*

**Keywords:** *In vivo, RF/Microwaves, Work in Progress*

**Presented by:** *Ye Ji Jeong*

To explore the chronic RF-EMF effect on gene expression in hippocampus of brains of mice at different age, we performed 8 months RF-EMF exposure to both young and aged C57BL/6 mice (SAR 5 W/kg, 2 hours/day, 5 days/week) and investigated the changes of gene expression profile using whole gene microarray approach. The genes in the hippocampus showed different patterns in young and aged brains. And we found a group of genes that changed commonly in both groups by RF-EMFs. These will be used as important basic data to identify the molecular biological mechanism of RF-EMFs.

## **PB-94 [15:00]**

### **Gestational RF-EMF exposure disrupts the maternal hypothalamic-pituitary-adrenal axis, but not placental barrier**

Hye Sun Kim<sup>1</sup>, Kang-Hyun Han<sup>3</sup>, Hyung Do Choi<sup>4</sup>, Jeong-Ki Pack<sup>5</sup>, Nam Kim<sup>6</sup> & Young Hwan Ahn<sup>1, 2</sup>

<sup>1</sup>*Department of Neurosurgery, Ajou University School of Medicine, Suwon, Korea, 16944*

<sup>2</sup>*Neuroscience Graduate Program, Department of Biomedical Sciences, Graduate School of Ajou University, Suwon, Korea, 16944*

<sup>3</sup>*Department of General and Applied Toxicology, Korea Institute of Toxicology, Daejeon, Korea, 34114*

<sup>4</sup>*Radio Technology Research Department, Electronics and Telecommunications Research Institute, Daejeon, Korea, 34129*

<sup>5</sup>*Department of Radio Sciences and Engineering, Chungnam National University, Daejeon, Korea, 34134*

<sup>6</sup>*School of Electrical and Computer Engineering, Chungbuk National University, Cheongju, Korea, 28644*

**Keywords:** *In vivo, RF/Microwaves, Completed (unpublished)*

**Presented by:** *Hye Sun Kim*

We examined the impact of RF exposure at whole-body SAR of 4 W/kg on maternal HPA axis and placental barrier. Gestational RF-EMF exposure at 4 W/kg SAR can cause a significant elevation of maternal level of cortisol, however fetus can be protected by placental barrier.

## **PB-96 [15:00]**

### **The structural and functional alterations of neurotransmission in central nervous system induced by RF-EMF exposure**

Ju-Hwan Kim<sup>1</sup>, Yang Hoon Huh<sup>2</sup>, Jin-Koo Lee<sup>1</sup>, Hyung-Gun Kim<sup>1</sup> & Hakrim Kim<sup>1</sup>

<sup>1</sup>*Department of Pharmacology, Dankook University, Cheonan, Korea, 31116*

<sup>2</sup>*Electron Microscopy Research Center, Korea Basic Science Institute, Ochang, Korea, 28119*

**Keywords:** *In vivo, RF/Microwaves, Completed (published)*

**Presented by:** *Ju-Hwan Kim*

The exposure to RF-EMF could affect the neurotransmission through altered profiles of synaptic vesicles in neuron, which might influence behavioral phenotype after long term exposure of RF-EMF and suggested that the exposure to RF-EMF could induce the structural and functional changes of neuron in the multiple pathways.

## **PB-98 [15:00]**

### **Intravital microscopic observation of modulatory actions of the angiogenesis under static magnetic field exposure**

Hiroshi Masuda<sup>1</sup>, Akimasa Hirata<sup>2</sup>, Akiko Nagai<sup>3</sup>, Itsuki Kageyama<sup>1, 2</sup>, Yoshitaka Morimatsu<sup>1</sup> & Tatsuya Ishitake<sup>1</sup>

<sup>1</sup>*Department of Environmental Medicine, Kurume University School of Medicine Kurume, Kurume, Japan, 830-0011*

<sup>2</sup>*Department of Computer Science and Engineering, Nagoya Institute of Technology, Nagoya, Japan, 466-8555*

<sup>3</sup>*Department of Anatomy, School of Dentistry, Aichi Gakuin University, Nagoya, Japan, 464-8650*

**Keywords: In vivo, Static, Work in Progress**

**Presented by: Hiroshi Masuda**

To observe dynamic changes in the angiogenic process under exposure to a static magnetic field, we improved on the traditional closed cranial window method for rodent animals. Male C57BL/6NCrSlc mice were used for this experiment and exposed to a static magnetic field using neodymium permanent magnets placed on the window. The improved method allowed for in vivo and repeated imaging of the angiogenesis in mouse brains under the exposure for one month. The angiogenic process at early stages seemed to be accelerated with the exposure.

## **PB-100 [15:00]**

### **Influence of electromagnetic fields on prooxidant/antioxidant balance in rat stomach**

Karolina Sieron<sup>1</sup>, Grzegorz Onik<sup>1</sup>, Ewa Birkner<sup>2</sup>, Grzegorz Cieslar<sup>3</sup>, Andrzej Krawczyk<sup>4</sup>, Pawel Sowa<sup>5</sup> & Aleksander Sieron<sup>6</sup>

<sup>1</sup>*Department of Physical Medicine, Chair of Physiotherapy, Medical University of Silesia in Katowice, Katowice, Poland, 40-752*

<sup>2</sup>*Chair of Biochemistry, Medical University of Silesia in Katowice, Zabrze, Poland, 41-808*

<sup>3</sup>*Department and Clinic of Internal Diseases, Angiology and Physical Medicine, Medical University of Silesia in Katowice, Bytom, Poland, 41-902*

<sup>4</sup>*University of Economics and Innovation, Lublin, Poland, 20-209*

<sup>5</sup>*Silesian University of Technology, Gliwice, Poland, 44-100*

<sup>6</sup>*Jan Dlugosz University in Czestochowa, Czestochowa, Poland, 42-200*

**Keywords: In vivo, RF/Microwaves, Completed (unpublished)**

**Presented by: Karolina Sieron**

Health consequences of exposure to high-voltage industrial frequency and radio-frequency electromagnetic fields are not clearly established. The study aim was to evaluate the impact of different electromagnetic fields on prooxidant and antioxidant processes in the stomach tissue of 40 male rats. Obtained results proved that four-week exposure to electromagnetic field emitted by typical high-voltage electric current transmission lines and a mobile leads to pro- and antioxidative status alterations in rat stomach.

## **PB-102 [15:00]**

### **nsPEF dramatically affects peritoneal carcinomatosis tumors in a syngeneic orthotopic graft murine model**

Abdelkader Taibi<sup>1</sup>, Marie-Laure Perrin<sup>2</sup>, Jérémie Albouys<sup>1</sup>, Catherine Yardin<sup>1</sup>, Sylvaine Durand-Fontanier<sup>1</sup> & Sylvia M. Bardet<sup>2</sup>

<sup>1</sup>*CNRS, CHU Limoges, XLIM, UMR 7252, University of Limoges, Limoges, France, F-87000*

<sup>2</sup>*CNRS, XLIM, UMR 7252, Limoges, France, F-87000*

**Keywords: In vivo, Pulsed, Work in Progress**

**Presented by: Sylvia M. Bardet**

New immunocompetent cancer models are still needed for the identification and preclinical validation of novel

therapeutic targets in colorectal cancer. We have developed 4 models by syngeneic intravenous, subcutaneous, intraperitoneal or laparotomy graft of luciferase expressing CT-26 cells with or w/o 10 ns PEF exposure, a promising tool for tumor ablation. Anatomic and histologic analysis corroborated the existence of tumoral nodules, and multiphoton microscopy was used to describe peritoneal tumoral fibrosis. In vitro CT-26 cells were also analyzed for their sensitivity to nsPEF (survival, mitochondrial potential, calcium waves and permeabilization). We were able to show a drastic effect of nsPEF on in vivo tumor morphology and survival.

**PB-104 [15:00]**  
**STUDENT PAPER**

**Manipulation of weak magnetic fields alters stem cell proliferation during regeneration**

Alanna Van Huizen<sup>1</sup>, Luke Kinsey<sup>1</sup>, Frank Barnes<sup>2</sup> & Wendy Beane<sup>1</sup>

<sup>1</sup>*Department of Biological Sciences, Western Michigan University, Kalamazoo, Michigan, USA, 49008-5410*

<sup>2</sup>*Department of Electrical, Computer, and Energy Engineering, University of Colorado, Boulder, Boulder, Colorado, USA, 80309-0425*

**Keywords:** *In vivo, Static, Completed (published)*

**Presented by:** *Alanna Van Huizen*

Weak magnetic fields (WMFs) can affect the rate of cellular proliferation. Using the planarian regeneration model, we show exposure to 200  $\mu$ T WMFs inhibits new tissue (blastema) growth, as compared to 45  $\mu$ T (earth-normal) controls. Growth inhibition occurred due to loss of reactive oxygen species (ROS) at the wound site, which reduced heat shock protein 70 expression (which in turn is required for stem cell proliferation). Variations in WMFs are thought to change electron spin states in radical molecules, thus affecting radical pair recombination rates. These data reveal that based on field strength, WMF exposure can increase or decrease new tissue formation in vivo, suggesting WMFs as a potential tool to manipulate mitotic activity.

**PB-106 [15:00]**  
**STUDENT PAPER**

**On the development of an imaging system at mm-wave frequencies for biological applications: dielectric characterization of tissues and first preliminary results on phantoms**

Simona Di Meo<sup>1</sup>, Marco Pasian<sup>1</sup>, Giulia Matrone<sup>1</sup>, Lorenzo Pasotti<sup>1</sup>, Lourdes Farrugia<sup>2</sup> & Charles Sammut<sup>2</sup>

<sup>1</sup>*Department of Electrical, Computer and Biomedical Engineering, University of Pavia, Pavia, Italy, 27100*

<sup>2</sup>*Electromagnetics Laboratory, Department of Physics, University of Malta, Msida, Malta, 2080*

**Keywords:** *Human, RF/Microwaves, Work in Progress*

**Presented by:** *Simona Di Meo*

In this abstract, the work still in progress done by the Microwave Laboratory of the University of Pavia is presented. The abstract addresses all the main aspects of the research from the dielectric characterization of human breast ex-vivo tissues (up to 50GHz) to the final test of the mm-wave imaging prototype on realistic breast phantoms. The future work regarding the dielectric characterization of in-vivo samples on a relatively small colony of mice is also presented, along with the current collaboration with the University of Malta mainly intended to assess (and possibly quantify) the statistical difference between the dielectric properties derived from ex-vivo samples taken from animals and taken from human cadavers.

**PB-108 [15:00]**

**Are there age-related differences in possible effects of RF-EMF exposure on the macro- and microstructure of sleep between healthy young (18-30 years) and healthy elderly men (60-80 years)?**

Torsten Eggert<sup>1</sup>, Hans Dorn<sup>1</sup>, Gernot Schmid<sup>2</sup>, Cornelia Sauter<sup>1</sup>, Rene Hirtl<sup>2</sup> & Heidi Danker-Hopfe<sup>1</sup>

<sup>1</sup>*Competence Center of Sleep Medicine, Charité - University Medicine Berlin, Berlin, Germany, D-12200*

<sup>2</sup>*EMC & Optics, Seibersdorf Laboratories, Seibersdorf, Austria, A-2444*

**Keywords:** *Human, RF/Microwaves, Completed (unpublished)*

**Presented by:** *Torsten Eggert*

The study aims to analyse possible differences in RF-EMF effects on the macrostructure and the microstructure of sleep between healthy young and healthy elderly men. The results indicate no clear differences in effects of GSM 900 and TETRA exposure in healthy young (18-30 years) and elderly men (60-80 years). The results observed so far are not indicative of a disturbed sleep under RF-EMF exposure.

**PB-110 [15:00]**  
**STUDENT PAPER**

**Specific absorption rate analysis of a dual-band planar monopole antenna with a metasurface resonator for 5G / WLAN applications**

Min-Joo Jeong<sup>1</sup>, Niamat Hussain<sup>1</sup>, Hanul Bong<sup>1</sup>, Ji Woong Park<sup>1</sup>, Seungwoo Lee<sup>2</sup> & Nam Kim<sup>1</sup>

<sup>1</sup>*College of Electrical and Computer Engineering, Chungbuk National University, Cheongju-si, Korea, 28644*

<sup>2</sup>*Korea Electric Power Research Institute, Daejeon, Korea, 34056*

**Keywords: Human, RF/Microwaves, Work in Progress**

**Presented by: Min-Joo Jeong**

In this paper, we present a dual-band planar monopole antenna using metasurface (MS) resonator with low specific absorption rate (SAR) for 5G and WLAN applications. The proposed antenna is designed by adding an MS resonator to a monopole antenna fed by a co-planar waveguide (CPW). We calculated the SAR for 1 g and 10 g tissue at 0 mm distance of antenna from the head instead of 10 mm, which is stricter than the international standards, and computed the SAR values at 3.5 GHz and 5.8 GHz. The SAR values are found to be 0.823 W/kg for 1 g and 0.584 W/kg for 10 g at 3.5 GHz and 1.3 W/kg for 1 g, and 0.877 W/kg for 10 g at 5.8 GHz, which are under the international safety SAR standards.

**PB-112 [15:00]**

**Characteristics of skin temperature elevation under the local exposure of 28 GHz-millimeter-wave in phantom and real human body**

Itsuki Kageyama<sup>1, 3</sup>, Takashi Hikage<sup>2</sup>, Keita Sakakibara<sup>2</sup>, Akimasa Hirata<sup>3</sup>, Sachiko Kodera<sup>3</sup>, Kenji Taguchi<sup>4</sup>, Tatsuya Kashiwa<sup>4</sup>, Yoshitaka Morimatsu<sup>1</sup>, Tatsuya Ishitake<sup>1</sup> & Hiroshi Masuda<sup>1</sup>

<sup>1</sup>*Department of Environmental Medicine, Kurume University School of Medicine, Kurume, Japan, 830-0011*

<sup>2</sup>*Graduate school of Information Science and Technology, Hokkaido University, Sapporo, Japan, 060-0814*

<sup>3</sup>*Department of Computer Science and Engineering, Nagoya Institute of Technology, Nagoya, Japan, 466-8555*

<sup>4</sup>*Department of Electrical and Electronic Engineering, Kitami Institute of Technology, Kitami, Japan, 090-8507*

**Keywords: Human, RF/Microwaves, Work in Progress**

**Presented by: Itsuki Kageyama**

There is little information about the biological effects of millimeter-waves (MMW) such as 5th generation wireless systems (5G) and WiGig (IEEE 802.11ad) on human body surface including the function of skin blood flow. Aim of this study was to develop new systems for local skin exposure of 28 GHz band and to evaluate temperature elevation at body surface under the local exposure in phantom and human body. The temperature elevation was found locally in and around the target area. In addition, obvious elevation of temperature was observed at 0.5 W of antenna input power in both surfaces.

**PB-114 [15:00]**

**Photonic bridges & EMF: a new approach to identify natural solutions to regulate ambroisa and reduce its allergic impact on human health**

Georges Vieilledent<sup>1</sup>, Bruno Taupier-Letage<sup>2</sup>, Raymond Herren<sup>3</sup> & Philippe Chovet<sup>4</sup>

<sup>1</sup>*Electrophotonique Ingenierie, Brens, France, 81600*

<sup>2</sup>*Institut de l'Agriculture et de l'Alimentation Biologique, Paris, France, 75000*

<sup>3</sup>*Consultant Technique, Paris, France, 75000*

<sup>4</sup>*Consultant Technique en préparation aqueuses, St Souplet, France, 51600*

**Keywords: Human, Optical, Work in Progress**

**Presented by: Georges Vieilledent**

In 2014, as part of BioEm's Annual Meeting (Cape Town, South Africa), we presented a poster on new applications of the corona effect and in particular on a phenomenon never before identified that we have called "photonic bridges". These phenomena seem to indicate an affinity or not between the products tested. In the context of the research for innovative solutions capable of inhibiting the development of ambrosia, a particularly invasive weed in agricultural environments and capable of causing strong allergic reactions, we present here the first results obtained with the use of photonic bridges. These promising results open up important research opportunities, particularly in the field of health

#### **PB-116 [15:00]**

##### **Absorption of RF energy in the cell layer of biological preparations**

Alessandra Paffi<sup>1</sup>, Asher Sheppard<sup>2</sup> & Quirino Balzano<sup>3</sup>

<sup>1</sup>*ICEmB at Sapienza University of Rome, Rome, Italy*

<sup>2</sup>*Asher Sheppard Consulting, Santa Rosa, CA, USA*

<sup>3</sup>*University of Maryland, College Park, USA*

**Keywords: Dosimetry (computational), RF/Microwaves, Work in Progress**

**Presented by: Alessandra Paffi**

The exposure of cell preparations to RF energy is often performed in Petri dishes supported by a metal ground plane, such as inside TEM cells or radial waveguides. Due to the thickness of the cell layer (order of  $10^{-5}$  m) at the bottom of a Petri dish, numerical tools used for dosimetric calculation present problems in managing the mesh. Here, we employ an analytic method for plane waves propagating through the cell layer and overlying medium. Our calculations suggest that a transverse resonance can occur if a wave incident on the medium surface excites a trapped wave. Although our calculations are obtained with an idealized model, they predict transverse resonant phenomena that are not easily anticipated by numerical EM computations.

#### **PB-118 [15:00]**

##### **Dipolar coupling between CW electric fields and water solution: a rationale for non-linear responses in molecular dynamics simulations**

Matteo Cellini<sup>1</sup>, Paolo Marracino<sup>1, 3</sup>, Alessandra Paffi<sup>1, 2</sup> & Guglielmo d'Inzeo<sup>1, 2</sup>

<sup>1</sup>*Department of Information Engineering, Electronics and Telecommunications (DIET), Sapienza University of Rome, Rome, Italy*

<sup>2</sup>*ICEmB, Genova, Italy*

<sup>3</sup>*RISE Technology, Rome, Italy*

**Keywords: Mechanistic/Theoretical, RF/Microwaves, Work in Progress**

**Presented by: Alessandra Paffi**

Many approaches for calculation of the field-dependent dielectric constant of water solutions rely on the Onsager and Kirkwood theories of polar dielectrics. Such basic theories implicitly consider the electric field applied to fulfill the so-called 'weak field conditions', i.e. to produce a linear response in the system. In this work we made use of molecular dynamics (MD) simulations to investigate possible non-linear effects induced by high intensity electric fields, specifically continuous waves burst with nanosecond duration, and eventually compare such effects with the ones predicted by the literature.

#### **PB-120 [15:00]**

##### **Molecular simulations of the A2A adenosine receptor in presence of magnetic field: an insight on the binding site environment**

Federico Del Signore<sup>1</sup>, Paolo Marracino<sup>2</sup>, Elena della Valle<sup>3</sup>, Davide Cocco<sup>1</sup>, Stefania Setti<sup>4</sup>, Ruggero Cadossi<sup>4</sup>, Micaela Liberti<sup>1</sup> & Francesca Apollonio<sup>1</sup>

<sup>1</sup>*DIET, University of Rome "La Sapienza, Rome, Italy;, Rome, Italy*

<sup>2</sup>Rise Technology srl, Via Monte Bianco 18, S. Martino di Lupari, Italy, Italy

<sup>3</sup>Bioelectronic Vision Lab, University of Michigan, Michigan, USA

<sup>4</sup>IGEA SpA, Via Parmenide 10/A, Carpi, Italy

**Keywords: Mechanistic/Theoretical, Static, Work in Progress**  
**Presented by: Francesca Apollonio**

In this paper, we present the results of the application of an external static magnetic field with the Velocity Verlet algorithm for performing Molecular Dynamics simulations of the A<sub>2A</sub> receptor protein embedded in a phospholipidic bilayer. Molecular Dynamics simulations allow to understand at molecular level the interaction mechanisms between atoms under specific conditions. Here MD simulations of a receptor protein have been performed in presence of an external magnetic field in order to try to elucidate specific endpoints of interaction with the field. In particular an insight on the binding site environment has been carried out.

**PB-122 [15:00]**

**WITHDRAWN**

**PB-124 [15:00]**

**Comparison between two electric conduction models related to Ohm's law and Drude's conductivity formula**

Hiromi Ozaki<sup>1, 2</sup> & Shoogo Ueno<sup>3, 4</sup>

<sup>1</sup>Formerly Nippon Steel Corporation, Tokyo, Japan

<sup>2</sup>10-14, Minami-Ohtsubo-cho, Shimonoseki, Japan, 750-0055

<sup>3</sup>Professor Emeritus, The University of Tokyo, Tokyo, Japan

<sup>4</sup>2-7-1-503, Mukai-shin-machi, Minami-ku, Fukuoka, Japan, 811-1345

**Keywords: Mechanistic/Theoretical, Static, Work in Progress**  
**Presented by: Shoogo Ueno**

From a point of electrical engineers' view, we are interested in electric conduction, in particular, microscopic movements of electric carriers in conductive materials such as electrically driven electron in copper wire of solid state. We studied the most fundamental law; Ohm's law and Drude's conductivity formula. The two models seem independent models, namely, the one model is a periodic-collision model and the other is a viscosity model. Our study, however, concludes that the two models have the same expression in both Ohm's law and Drude's conductivity formula. The results obtained in this study are useful in understanding electric conductivities in conductive materials used in bioelectricity and bioelectromagnetics.

**PB-126 [15:00]**

**WITHDRAWN**

**PB-128 [15:00]**

**Evaluation of EMF emitted by WiFi modems in laptops' ergonomical use**

Krzysztof Gryz<sup>1</sup>, Jolanta Karpowicz<sup>1</sup> & Patryk Zradziński<sup>1</sup>

<sup>1</sup>Laboratory of Electromagnetic Hazards, Central Institute for Labour Protection - National Res. Inst. (CIOP-PIB), Warszawa, Poland, 00-701

**Keywords: Occupational, RF/Microwaves, Work in Progress**  
**Presented by: Krzysztof Gryz**

The exposure to electromagnetic field (EMF) emitted by WiFi modems of laptops were evaluated by numerical simulations of the specific absorption rate (SAR) values in virtual human body models (male and female). The results of numerical calculation of SAR values in human models were below limits when considered exposure scenarios were ergonomically realistic, but shown significantly higher EMF exposure effects while using laptop closer to the body. When EMF exposures caused by the use of portable computer device, the ergonomics of exposure conditions in the exposure scenarios need to be considered. Further

analysis with next exposure scenarios are under considerations.

### **PB-130 [15:00]**

#### **Assessment of occupational exposure during arc welding**

Lucien Hammen<sup>1</sup>

<sup>1</sup>*Electromagnetism, Vibration and Optics Laboratory, French National Institute for Occupational Health and Safety, Vandoeuvre les Nancy, France, 54519*

**Keywords: Occupational, ELF/LF, Completed (unpublished)**

**Presented by: Lucien Hammen**

Arc welding stations are widely use in the industry. During the process the worker is exposed to an EMF and an associated risk assessment has to be done. Because of the inhomogeneous field distribution over the welder, the compliance should be determined using ELVs comparison. This study has identified the influencing parameters and their effects. The B field determination was based on a comparative method between theoretical and experimental distributions. The internal E field was estimated using 2 different approaches: the use of a standard (IEC62822-2) and numerical simulation. It shows that for some configurations the ELVs could be exceeded. It will provide some guidances to ensure that worker exposure doesn't exceed the field limits.

### **PB-132 [15:00]**

#### **Long term load from the exposure to static magnetic field during workers activities in magnetic resonance medical diagnostics**

Jolanta Karpowicz<sup>1</sup>

<sup>1</sup>*Laboratory of Electromagnetic Hazards, Central Institute for Labour Protection - National Res. Inst. (CIOP-PIB), Warszawa, Poland, 00-701*

**Keywords: Occupational, Static, Completed (unpublished)**

**Presented by: Jolanta Karpowicz**

The aim of the study was to estimate long term load from SMF near 1.5 T MRI scanners used for regular medical diagnostics. Taking into account the usual work practice in the MRI centers, the most frequently only the radiographers' exposure needs to be analyzed with respect to the long term SMF load. It was found that in routine examination of one patient the radiographer is exposed to SMF>0.5mT over 1-7minutes and SMF dose is 0.06(0.1)Txmin, median(maximum) value. During several decades of possible work activities SMF load of radiographers may exceed the threshold for possible developing of hypertension from the long term exposure to MRI-related SMF (dose>7500Txmin). In further epidemiological studies they need to be considered.

### **PB-134 [15:00]**

#### **Occupational environments where electromagnetic fields exposure can exceed Directive 2013/35/EU limits: identification of scenarios and preliminary measurement survey**

Rosanna Pinto<sup>1</sup>, Angela Coniglio<sup>2</sup>, Gian Marco Contessa<sup>3</sup>, Simona D'Agostino<sup>4</sup>, Rosaria Falsaperla<sup>4</sup>, Vanni Lopresto<sup>1</sup> & Alessandro Polichetti<sup>5</sup>

<sup>1</sup>*Division of Health Protection Technologies, ENEA, Rome, Italy*

<sup>2</sup>*San Giovanni Calabita Fatebenefratelli Hospital, Rome, Italy*

<sup>3</sup>*Institute of Radiation Protection, ENEA, Rome, Italy*

<sup>4</sup>*Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, INAIL, Monte Porzio Catone, Italy*

<sup>5</sup>*National Center for Radiation Protection and Computational Physics, ISS, Rome, Italy*

**Keywords: Occupational, ELF/LF, Work in Progress**

**Presented by: Rosanna Pinto**

In this paper a scientific review is presented, aimed to the identification of occupational scenarios where the exposure to stray electromagnetic fields (EMFs) can exceed the exposure limit values (ELVs) defined in

Directive 2013/35/EU. A total number of 56 papers was examined, and some critical exposure scenarios have been selected for further deepening. Among these, a device for transcranial magnetic stimulation (TMS) was chosen for a first measurement survey. Preliminary results of operators' exposure assessment are shown.

#### **PB-136 [15:00]**

**WITHDRAWN**

#### **PB-138 [15:00]**

##### **EMF measurement approaches for 5G – spot and long-term measurements**

Holger Schwarz<sup>1</sup> & Sabine Duerr<sup>1</sup>

<sup>1</sup>*Narda Safety Test Solutions GmbH, Pfullingen, Germany, 72793*

**Keywords: Public Health Policy, RF/Microwaves, Work in Progress**

**Presented by: Holger Schwarz**

With 5G there are new sources of electromagnetic emissions to be considered. There is already some public concern and discussion about new frequencies used by 5G and the new technologies. Narda and Telstra have performed instantaneous spot measurements for health & safety at work assessments, and also long-term measurements as an approach for environmental assessment purposes. Additionally we have assessed the safe work procedures for working safely on 5G base stations.

#### **PB-140 [15:00]**

##### **Derivation of an averaging time threshold for U.S. FCC time constraints on impulse heating from localized exposure**

Martin Doczkat<sup>1</sup> & Edwin Mantiply<sup>2</sup>

<sup>1</sup>*Office of Engineering and Technology, Federal Communications Commission, Washington, DC, USA, 20554*

<sup>2</sup>*Retired, Office of Engineering and Technology, Federal Communications Commission, Washington, DC, USA, 20554*

**Keywords: Standards, RF/Microwaves, Completed (unpublished)**

**Presented by: Martin Doczkat**

For typical consumer devices, instantaneous exposures are time-averaged based on an inherent property or duty-cycle of a device, such as over a single time slot in a TDMA transmission scheme. New technologies enable a device to actively monitor potential exposure to its user over longer times. Averaging time thresholds are derived based on the FCC SAR limit of 1.6 W/kg over 1-g of tissue. This method is a simple alternative to more complex detailed anatomical modeling analyses which consider other effects such as heat conduction, blood flow, convection, and evaporation (which tend to shed heat away from the body), while arriving at similar conclusions – about 100 seconds at 3 GHz, to a couple of seconds at 100 GHz.

#### **PB-142 [15:00]**

##### **Telstra's EME assessment and preparation for 5G in Australia**

Mike Wood<sup>1</sup> & Debbie Wills<sup>1</sup>

<sup>1</sup>*Networks, Telstra Corporation, Melbourne, Australia, 3000*

**Keywords: Standards, RF/Microwaves, Work in Progress**

**Presented by: Mike Wood**

This paper looks at the preparation for 5G and extensive electromagnetic emissions (EME) testing and analysis on the Telstra 5G trial networks and the new 3.5GHz commercial network in Australia.

#### **PB-144 [15:00]**

##### **Evaluation of the IEC-62232:2017 standard for radiocommunication base stations with focus on**

## **children**

Richard Überbacher<sup>1</sup>, Gernot Schmid<sup>1</sup> & Stefan Cecil<sup>1</sup>

<sup>1</sup>*EMC & Optics, Seibersdorf Laboratories, A-2444 Seibersdorf, Austria*

**Keywords: Standards, RF/Microwaves, Work in Progress**

**Presented by: Gernot Schmid**

The IEC 62232:2017 standard describes methods to ensure compliance of base stations regarding to EMF safety of humans. In this work we investigate the robustness of the proposed standard spatial averaging scheme applied to children. In numerical simulations with an optical method a complex virtual test site was generated from an existing real exposure scenario. The results suggests, that for children because of their smaller stature the standard 9-point averaging scheme leads to an underestimation of the exposure in the vicinity of base stations. For a future release of the IEC 62232 further considerations for the EMF exposure of children or smaller persons are recommended to ensure the compliance with the safety limits.

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Hydro-Québec is a public utility that manages the generation, transmission and distribution of electricity in Quebec. It was established by the Government of Quebec in 1944 from the expropriation of private firms. This was followed by massive investment in hydro-electric projects like the James Bay Project. Today, with 63 hydroelectric power stations, the combined output capacity is 37,370 megawatts. Extra power is exported from the province and Hydro-Québec supplies 10 per cent of New England's power requirements. Hydro-Québec is a state-owned enterprise based in Montreal. In 2018, it paid CAD\$2.39 billion in dividends to its sole shareholder, the Government of Québec. Its residential power rates are among the lowest in North America. More than 40 percent of Canada's water resources are in Québec and Hydro-Québec is the fourth largest hydropower producer in the world. The company logo, a stylized "Q" fashioned out of a circle and a lightning bolt, was designed by Montreal-based design agency Gagnon/Valkus in 1960.



Réseau de Transport d'Électricité (Electricity Transmission Network), usually known as RTE, is the electricity transmission system operator of France. It is responsible for the operation, maintenance and development of the French high-voltage transmission system, which at approximately 100,000 kilometres (62,000 mi), is Europe's largest. RTE is a wholly owned subsidiary of the partially public-owned French generator Électricité de France (EdF), headquartered in Paris. It is a limited liability corporation, known in France as a société anonyme.



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The Electric Power Research Institute, Inc. (EPRI), is an American independent, nonprofit organization that conducts research and development related to the generation, delivery, and use of electricity to help address challenges in electricity, including reliability, efficiency, affordability, health, safety, and the environment. EPRI's principal offices and laboratories are located in Palo Alto, California; Charlotte, N.C.; Knoxville, TN; and Lenox, MA.

## Other Sponsors



Occitanie is an administrative region of France that was created on January 1, 2016 from the former French regions of Languedoc-Roussillon and Midi-Pyrénées. France's Conseil d'État approved Occitanie as the new name of the region on September 28, 2016, coming into effect on September 30, 2016. The modern administrative region is named after the cultural and historical region of Occitania, which covers a larger area. The region as it is today covers a territory similar to that ruled by the Counts of Toulouse in the 12th and 13th centuries. The banner of arms of the Counts of Toulouse, known colloquially as the Occitan cross, is used by the modern region and is also a popular cultural symbol. The new region covers an area of more than 72,724 km<sup>2</sup> (28,079 square miles), and has a population of 5,626,858. It borders Nouvelle-Aquitaine, Auvergne-Rhône-Alpes, Provence-Alpes-Côte d'Azur, Andorra (Canillo, Encamp, La Massana, Ordino) and Spain (Aragon and Catalonia). [From Wikipedia] <https://www.regionlrmp.fr>



École Pratique  
des Hautes Études



L'École Pratique des Hautes Études est un grand établissement où l'on pratique la recherche en Sciences de la vie et de la terre, Sciences historiques et philologiques, et Sciences religieuses. Son enseignement est dispensé au niveau master, doctorat et post-doctorat ainsi que pour la préparation de son diplôme propre. Elle accueille depuis toujours des auditeurs libres. L'EPHE couvre des territoires de la connaissance originaux. Participer aux conférences et autres enseignements qui y sont dispensés par plus de 260 enseignants-chercheurs, c'est pratiquer la recherche dans des champs aussi variés que les langues et les religions de l'Asie centrale pré-islamique, les grands monothéismes, l'archéologie chinoise, la paléographie hébraïque ou la dialectologie grecque et les humanités numériques pour les sciences humaines et sociales ; la biodiversité des récifs coralliens, les neurosciences et les cognosciences, l'environnement et la régulation cellulaires pour les sciences de la vie et de la terre... sans oublier les questions transdisciplinaires qui se posent à l'interface de ces grands domaines du savoir. À sa création en 1868, l'EPHE avait pour mission d'introduire dans le monde universitaire un mode original de formation fondé sur la fréquentation de séminaires et le travail en laboratoire. Elle comprenait alors quatre sections : Mathématiques, Physique et chimie, Sciences naturelles et physiologie, et Sciences historiques et philologiques. Une Ve section de Sciences religieuses y fut adjointe en 1886. La VIe section, dévolue aux Sciences économiques et sociales, créée en 1947, s'autonomisa en 1975 pour devenir l'EHESS. À la même époque, les sections de mathématiques et de physique-chimie furent dissoutes. Fidèle à sa mission initiale, l'EPHE continue de former à la recherche par la pratique de la recherche, mais en s'adaptant au nouveau paysage scientifique mondial : ses chercheurs et ses doctorants tissent un intense réseau international ; nombre de ses équipes sont contractualisées avec le CNRS ou d'autres organismes ; elle est membre de l'Université PSL où elle collabore avec d'autres prestigieux établissements ; elle est partie prenante du projet Campus Condorcet, la Cité des humanités et sciences sociales qui se bâtit à Aubervilliers. Attentive aux enjeux sociétaux des questions scientifiques qu'elle étudie, l'EPHE a trois instituts qui offrent des formations et exercent une fonction d'observatoire : l'Institut européen en sciences des religions, l'Institut des récifs coralliens du Pacifique et l'Institut transdisciplinaire d'étude du vieillissement. *Ecole Pratique des Hautes Études (EPHE)* <https://www.ephe.fr>



*maîtriser le risque  
pour un développement durable*

L'Institut national de l'environnement industriel et des risques (INERIS) est un établissement public à caractère industriel et commercial (EPIC) créé en 1990 et placé sous la tutelle du Ministère de la Transition Ecologique et Solidaire français. Il est pour 80 % l'héritier du CERCHAR, Centre d'Etudes et Recherches des Charbonnages de France (1947-1990) et pour 20 % de l'IRCHA, l'Institut National de Recherche Chimique Appliquée. Sa mission est d'évaluer et de prévenir les risques accidentels ou chroniques pour l'homme et l'environnement liés aux installations industrielles, aux substances chimiques et aux exploitations souterraines. L'établissement compte deux sites, l'un à Verneuil-en-Halatte dans l'Oise (avec une grande partie des salariés) et un autre à Nancy. Il dispose également d'équipes à Bourges, Lyon et Aix-en-Provence.



La Société Française de Radioprotection (SFRP) est née en 1965 de la fusion de deux précédentes Sociétés : la Société de Radioprotection créée sur l'initiative du Docteur Henri Jammet et la Section Française de la Société Américaine "Health Physics Society" mise en place par Monsieur Francis Duhamel. Le général Norbert Chassende-Barroz fut le Président fondateur de la SFRP. La déclaration de création, sous le régime des associations sans but lucratif, a été déposée en préfecture le 18 février 1965. La Commission Juridique et du Règlement veille à la conformité des actions de l'Association au regard des statuts et des règlements intérieurs. La revue "Radioprotection" a été créée en 1966 avec pour objectif d'être la revue scientifique française consacrée à la Radioprotection, mais aussi le bulletin officiel de l'Association. La Commission de la Revue, qui assure la réalisation des quatre numéros annuels, a su préserver, au cours du temps, cette double vocation. Depuis son adhésion, en juin 1965, à l'Association Internationale de Radioprotection (IRPA), la SFRP a constamment contribué à la promotion de la radioprotection française au plan international. Dans la composition actuelle du conseil exécutif de l'IRPA, le poste de secrétaire général est tenu par Bernard Le Guen membre du conseil d'administration de la SFRP. Dans ce cadre, l'Association entretient des relations privilégiées avec des Sociétés européennes, en vue d'échanger les expériences et contribuer en commun à la mise en œuvre des concepts, de la réglementation et des techniques de la radioprotection. Ainsi, par exemple, la SFRP organise régulièrement, en France ou à l'étranger, des manifestations en collaboration avec les Sociétés belge, britannique, espagnole, germano-suisse et italienne affiliées à l'IRPA. La SFRP a adopté le code de l'éthique de l'IRPA. La SFRP compte 1300 membres actifs et une dizaine de membres bienfaiteurs.



**La science pour la santé** \_\_\_\_\_  
\_\_\_\_\_ **From science to health**

The *Institut national de la santé et de la recherche médicale* (Inserm, the French National Institute of Health & Medical Research) is the only public sector research institution in France exclusively dedicated to human health. Under the dual aegis of the Ministries of Health and Research, Inserm has a budget of 998 million euros and employs 15,000 scientists, engineers and technicians all with one shared objective, namely to promote health—by advancing knowledge about living organisms and their diseases, developing innovative treatment modalities and conducting research on public health. Inserm has more than 365 research units spread across France and internationally. These are supported by 13 Regional Commissions for local oversight. Scientific activities are organized around 9 “Inserm Thematic Institutes”, corresponding to the main fields of biomedical and health research. Since its foundation in 1964, Inserm has played a part in many key, historic medical advances, including the first prenatal diagnostic tests, how the HLA system works, the first in vitro fertilisation, identification of the Human Immunodeficiency Virus, radiotherapy for cancer, the first skin grafting, deep brain stimulation and gene therapy. Inserm is the leading academic patent applicant in European biomedical research, the 6th applicant in France across all sectors, the 2nd in the field of biotechnology and the first in pharmaceuticals (2016 European Patent Office figures). In 2016, Inserm held a portfolio of 1,555 live patent families. Inserm Transfert, its private subsidiary responsible for managing the Institute’s intellectual property, has issued licenses for over a quarter of this portfolio to companies in France and around the world (including big commercial health care groups, intermediate-sized enterprises, SMEs or start-ups). On average, some ten spin- off companies are created each year. In 2016, Inserm was the 9th most innovative public sector research institution in the world, according to Thomson-Reuters. <http://www.inserm.fr>

## Exhibitors



Exem est un laboratoire accrédité spécialisé dans le contrôle et la surveillance de l'exposition des personnes aux champs électromagnétiques. Nous accompagnons les particuliers et les collectivités territoriales pour le contrôle des lieux publics et des habitations, les sociétés face à la réglementation sur l'exposition des travailleurs et les maîtres d'oeuvre pour l'obtention de la certification HQE. Soucieuse de cet enjeu sociétal, Exem accompagne le développement des nouvelles technologies et des projets liés à la connectivité en assurant le respect des seuils fixés par la réglementation. <https://www.exem.fr>



Since its inception in 1986, Microwave Vision Group (MVG) has developed a unique expertise in the visualization of electromagnetic waves. The Group's mission is to extend this unique technology to all sectors where it will bring strong added value. Year after year, the Group develops a complete range of Radio Frequency (RF) instruments to measure the level of exposure to electromagnetic fields and to address the following needs: • To continuously record the electromagnetic field level and alert the user to potential overexposure. • To monitor actual levels and compare them to the regulatory limits. • To address public concern through appropriate communication. • To simulate EMF radiation in real environments.



Cobham Microwave France has a long term experience in design and manufacture of Microwave Components and Systems for space, defense & security, industrial, scientific and medical applications. Our areas of capabilities are Silicon Diodes, RF & Microwave Modules, Isolators & Circulators, Filters & Duplexers, Waveguides and Systems. Our products are qualified and embedded on major space, defense & security, industrial, scientific and medical programmes and platforms worldwide.

## Vector SAR

Specific absorption rate (SAR) is a measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency electromagnetic field (EMF) and must be evaluated during the production of smartphones. This project will provide the methods, software tools and datasets required for traceable calibration and uncertainty analysis of vector probe array systems (array of vector probes that automatically determines the 3D electromagnetic field mapping using amplitude and phase information through a 3D reconstruction algorithm), which are used to measure the SAR of emitting mobile telecommunication devices. This work will contribute to the international standard IEC 62209-3 and future standardisation of fifth generation (5G) devices within IEC Technical Committee TC 106. This project will enable the full-compliance of mobile telecommunication devices against IEC 62209-3 in terms of EMF exposure limits to be tested with better reliability, and will enable testing times to be reduced, which will benefit the telecommunications industry.

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