

# Report EFS Concluding Symposium 2015



Website: <http://esfmeeting2015.icfo.eu/>

## Introduction

The ESF-concluding symposium of PlasmonBionanoSense during 24 and 25 September gathered 52 researchers to discuss and explore the frontiers in the field of plasmonics and sub-wavelength optics applied to biological applications, especially bio-sensing towards the level of individual biomolecules. The meeting took place at ICFO, the institute of Photonic Sciences in Castelldefels, Barcelona (Spain), the host institute of the co-chair of the ESF program. ICFO is ideally equipped for scientific workshops and discussion sessions (see <http://www.ICFO.eu> for information about the centre). Obviously the crucial sponsorship of ESF was prominently mentioned and visibly displayed throughout the meeting.

The particular objective of this closing symposium has been to gather the main players of the ESF program for a last time and display the main advances of the program, as always with a special emphasis on stimulating interaction between young and more experienced researchers. To this end, several PIs were invited from the program committee and selection committee of the countries participating to the ESF program, complemented by characteristic prominent researchers in the field.

The concluding symposium covered a variety of topics, all connected to biosensing by nanoscale control of light, and intimately connected to the theme of ESF program PlasmBioNanoSense. As such several applications in biology were put forward, such as plasmon-enhanced micro-spectroscopy in visible and infrared, nanoscale thermal control, the use of nanoplasmonic forces to trapping single nanoparticles, nanoantennas for nanoimaging, single biomolecule detection at high concentration, microfluidics, etc.... At the same time electrons keep on being an important tool to characterize plasmonic modes and e-beam probing of plasmon modes was a topic at the workshop. Finally more specialized topics on single molecule detection and advanced nanofabrication formed part of the program.

The symposium was a great success due to high level of speakers and presentations. The meeting was very vibrant, with a large number of questions after each talk, with permanent scientific discussions, many contacts and collaboration. Also at coffee breaks discussions continued; a truly buzzing scientific atmosphere permeating ICFO during the two days.

## Scientific Content

Here an overview of the more relevant topics and contributions presented at the ESF meeting.

The giant enhancement of local field at ultrasmall resonant nanoplasmonic particles allows to detect discrete on-off (de)attachment of single proteins. Michel Orrit from Leiden showed latest results of these quite impressive advances.

Detection local plasmonic fields with nm resolution has always been a challenge. Electron beams keep on being a universal tool to characterize nanoplasmonic structures. Especially electron energy loss spectroscopy (EELS) provides direct spatial frequency maps of plasmonic modes. Elementary plasmon modes with electron probes were revisited. Joachim Krenn from Graz, Austria, has specialized on EELS, applied to a wide range of optical antenna with various symmetries.

The ultimate dream in nanosensing would be succeed in NMR at molecular or single protein level. The diamond Nitrogen-vacancy centre provides an optical way to detect local spins, thus might one day enable single protein spin detection. The group of Fedor Jelezko in Ulm is making rapid advances in this direction. Unfortunately Fedor could not be present and instead postdoc Liam McGuinness gave a very instructive display of the concept and advances in local spin sensing, including recent results on SiO<sub>2</sub> layers.

Beyond sensing the biomolecules need to be interacting with the plasmonic sensor in a reversible way, with variable concentration and best parallel readout of various species. Thus liquid handling and microfluidic switching is equally important to make the plasmonic sensors to use. Both Romain Quidant of ICFO and Jiri Homola from Prague presented several microfluidic platforms, again with sensitivities to the few molecule level. Hatice Altug pushed the sensing towards the infrared and even MIR finger print regime to allow specific spectral recognition of IR and Raman bands and thus identify the proteins.

Plasmonic fields do exert forces on the nanoscale, allowing trapping of single nanoparticles. At the meeting Romain Quidant of ICFO presented advances on the optical forces plasmonic fields; on stochastic near field 3D microscopy using Brownian metallic nanoparticles; and on the cooling and amplification of a vacuum-trapped nanoparticle. He also addressed the nanoscale plasmonic control of heat inside cells and tissue, a field coined as thermoplasmonics.

Detection of single molecules through fluorescence is routine while detection by photo-thermal or plasmonic interaction is still state-of-the-art at the limits of realistic S/N. Thus alternatives are required. Direct absorption detection was presented by Vahid Sandoghdar of MPI-Erlangen, using cryogenic schemes with very strong molecule field interaction by matching both the narrow low-temperature spectral resonance and the spatial modal fields.

In a realistic biological environment the concentrations of proteins and enzymes are typically at the micromolar level, to ensure sufficient density for interaction. Yet single molecule sensing

requires ultrapure systems rather with nanomolar concentrations. Thus an important challenge is to reduce the detection volume towards the protein dimensions and thus allow higher concentrations. Jerome Wenger of Fresnel Institute, presented an ultra small gap-antenna system with screening from back ground to indeed reach micromolar concentration and still detect individual proteins.

A fundamental problem in plasmonics is given by the metal losses. On sub-100nm nanoparticles the losses are quite negligible, yet at distances beyond 1 micron the losses dominate. Apart from intrinsic material losses (imaginary part of epsilon) in practice the non-crystalline composition and surface roughness of metal are the the main `problem. David Norris of ETH presented quite spectacular template stripping of gold from a silicon V-groove to produce ultra-smooth gold wedges with propagation over 10-50 micron. Surely the effective coupling and reading-out of local light sources over such distances will highly benefit on these fabrication tricks. Particularly it opens routes to the study of ultrafast coherent energy transfer on the nanoscale, the strong coupling of organic molecules over larger macroscopic distances and the role vacuum field effects.

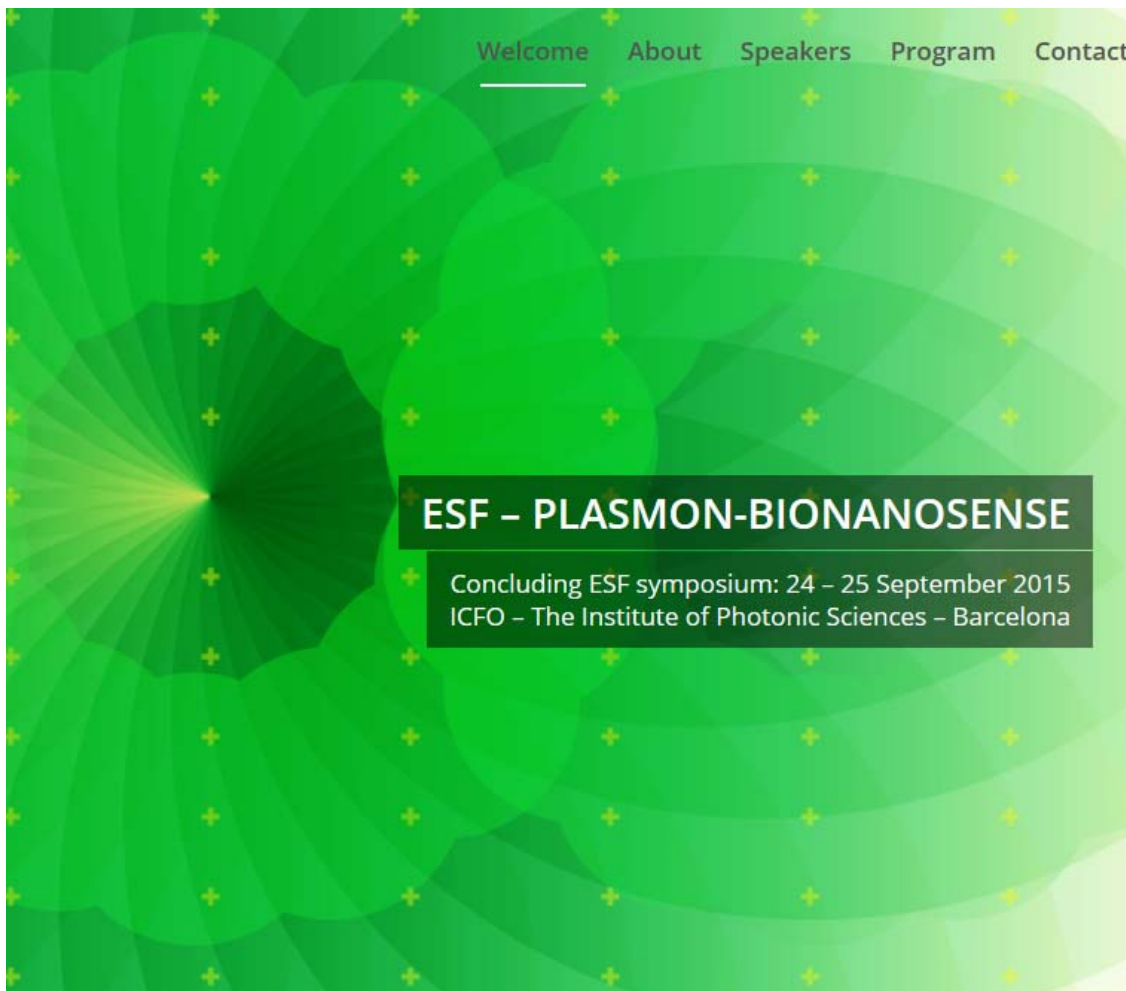
Beyond sensing come imaging. Plasmonic imaging in principle could reach the sub-10nm level exploiting the nano-focusing by plasmonic antennas. Maria Garcia-Parajo presented nanoantenna scanning microscopy using various types of antennas: subwavelength apertures, bowtie apertures and monopole antenna, reaching the sub 20nm level and localization accuracy on the Angstrom level. At the same time the nano-antenna hotspots are ideal for high concentration detection through fluorescence correlation spectroscopy.

The meeting was concluded by presentations of Stefan Maier and Niek van Hulst. Highlights of 5 years ESF program were reviewed. The long list of ESF-RNP supported Meetings/Workshops, network exchanges and visits were discussed and reviewed. An important level of internationalization has been achieved through the ESF-RNP. Significant mobility between UK, Spain and Germany should be mentioned, while later on in the network increasing visits to/from Czech Republic, Austria, Sweden, Ireland, and Portugal were realized. The exchange grants and short includes a large list of nationalities: FR, DE, UK, ES, IT, BY, PT, AT, CH, UA, IS, CZ, GR, HR, CA, IE, IL, LT, CN, RO, SG.

Obviously many attendees inquired about the future prospect of a similar ESF network. The coordinators are surely willing to make another bid when appropriate with the ESF.

The meeting was concluded with an address of thankfulness to the European Science Foundation.

# Website front-page - ESF Concluding Symposium 2015



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## ESF - PLASMON-BIONANOSENSE

New Approaches to Biochemical Sensing with Plasmonic Nanobiophotonics

The **European Science Foundation** network "New Approaches to Biochemical Sensing with Plasmonic Nanobiophotonics" (Plasmon-BioNanoSense) was launched in 2010 with the central goal of establishing a highly interdisciplinary community of scientists crossing the boundaries of the physical sciences (physics, materials science, chemistry), the biochemical sciences, and engineering, unified by the common objective of work towards optical nanobiosensors. The initial network grouping included expertise in the fundamentals of nanophotonics (theory and experiment), nanofabrication and nanotechnology, single-molecule spectroscopy, micron-scale biosensors, and photonic technology. The work programme of the network can be broadly divided into a number of research themes, such as control of light/matter interactions in electromagnetic field hot spots (the "sensing site"), steering of molecules into the sensing site ("agent delivery"), fundamental work on hot spot creation and nanoscale waveguides for superfocusing of light, optical and electrical read out, and integration. The network has supported many conferences, workshops and exchange visits between **ESF** partner countries on the topic.

The September 2015 meeting at ICFO concludes the **ESF** network. For this special occasion we have gathered main players in the field of Plasmon-BioNanoSense.

### CHAIRS



**STEFAN MAIER**  
Imperial College London  
Department of Physics  
London  
United Kingdom



**NIEK VAN HULST**  
ICFO - The Institute of Photonic  
Sciences  
Castelldefels (Barcelona)  
Spain

### PARTNERS



# SPEAKERS

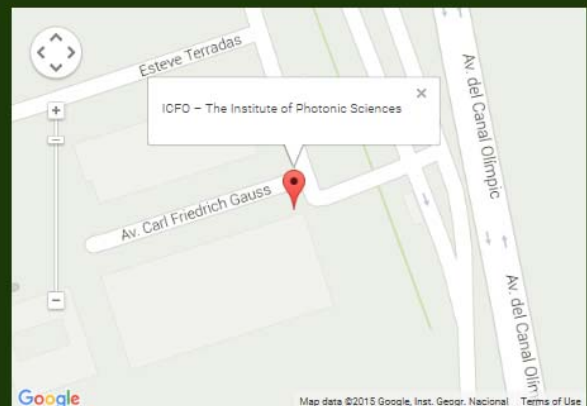
MICHEL ORRIT	Leiden, NL
MIKAEL KÄLL	Chalmers, Sweden
VAHID SANDOGHDAR	MPL, Germany
HATICE ALTUG	EPFL, Switzerland
LIAM MCGUINNESS	Ulm, Germany
JEROME WENGER	Fresnel, France
JOACHIM KRENN	Graz, Austria
DAVID J NORRIS	ETH, Switzerland
ONDREJ STRANIK	IPHT, Jena, Germany
MARÍA GARCÍA PARAJO	ICFO
ROMAIN QUIDANT	ICFO

# CONTACT / REGISTRATION

## CONTACT & REGISTRATION

Ester Tarrago – ICFO Events, Corporate Communications  
e-mail: [esfmeeting@icfo.eu](mailto:esfmeeting@icfo.eu)

- \* Registration is mandatory and should be done by e-mail
- \* The ESF meeting is free of charge
- \* Coffee, refreshments & lunch are included



# PROGRAM

## THURSDAY, SEPTEMBER 24

09:00	Welcome, Introduction
09:30	Michel Orrit (Leiden, NL)
10:20	Joachim Krenn (Graz, AU)
11:10-11:40	Coffe Break
11:40	Fedor Jelezko (Ulm, DE)
12:30	Romain Quidant (ICFO-Barcelona)
13:20-15:00	Lunch break, Granvia Mar
15:00	Vahid Sandoghdar (MPL-Erlangen, DE)
15:50	Mikael Käll (Chalmers, SE)
16:40-17:00	Refreshments
17:00	Jerome Wenger (Fresnel, Marseille, FR)
17:50	Jiri Homola (Prague, CZ)
20:00	Dinner – Fosbury Restaurant (Castelldefels)

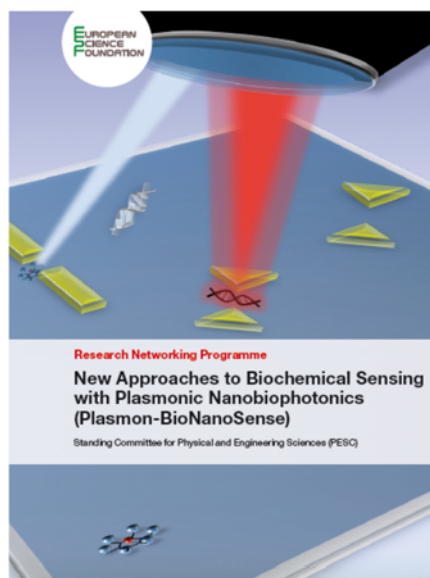
## FRIDAY, SEPTEMBER 25

09:00	Hatice Altug (EPFL, CH)
09:50	David Norris (ETH, CH)
10:40-11:10	Coffe Break
11:10	María García-Parajo (ICFO-Barcelona)
12:00	Ondrej Stranik (IPHT, Jena, DE)
12:50-15:00	Lunch Break, Gran Via Mar
15:00	Stefan Maier (Imperial, London, UK)
15:50	Niek Van Hulst (ICFO-Barcelona) <b>Conclusion</b>
16:15	End of ESF Symposium





**The location: ICFO – the Institute of Photonic Sciences**



## List of Participants ESF Concluding Symposium 2015

TITLE	NAME	SURNAME	NATIONALITY	SEX	ADDRESS	ZIP CODE	TOWN	COUNTRY	AFFILIATION	EMAIL
Prof.	MICHEL	Orrit	France	Male	Niels Bohrweg 2	2311	Leiden	Netherlands	Universiteit Leiden	Orrit@physics.leidenuniv.nl
Prof.	VAHID	SANDOGHDAR	Iran	Male	Günther-Scharowsky-Straße 1/Bldg. 24	91058	Erlangen	Germany	Max Planck Institute for the Science of Light	vahid.sandoghdar@mpl.mpg.de
Prof.	HATICE	Altug	Turkey	Female	Route Cantonale, 1015	3316	Lausanne	Switzerland	EPFL, École Polytechnique Fédérale de Lausanne	hatice.altug@epfl.ch
Prof.	JEROME	Wenger	France	Male	Avenue Escadrille Normandie-Niémen	13013	Marseille	France	Institut Fresnel	jerome.wenger@fresnel.fr
Prof.	JOACHIM	Krenn	Austria	Male	Universitätsplatz 3	8010	Graz	Austria	University of Graz	joachim.krenn@uni-graz.at
Prof.	Mikael	Käll	Sweden	Male	Maskingränd 2	41296	Gothenburg	Sweden	Chalmers University of Technology	mikael.kall@chalmers.se
Prof.	DAVID J	Norris	USA	Male	Raemistrasse 101	4058	Basel	Switzerland	ETH Zürich	dnorris@ethz.ch
Dr.	ONDREJ	Stranik	Czech Rep.	Male	Albert-Einstein-Straße 9	07745	Jena	Germany	IPHT, Institute of Photonic Technology	ondrej.stranik@ipht-jena.de
Prof.	STEFAN	Maier	Germany	Male	London SW7 2AZ	SW7 2AZ	Kensington	London	Imperial College London	s.maier@imperial.ac.uk
Dr.	LIAM	McGuinness	Australia	Male	89069 Ulm	89069	Ulm	Germany	Ulm University	liam.mcguinness@uni-ulm.de
Prof.	MARÍA	García-Parajo	Spain	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	maria.garcia-parajo@icfo.es
Prof.	NIEK	van Hulst	Netherlands	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	Niek.vanHulst@icfo.eu
Prof.	ROMAIN	Quidant	France	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	romain.quidant@icfo.es
Mrs.	Shahzad	Parsa	Iran	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	shahzad.parsa@icfo.es
Mr.	Renwen	Yu	China	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	renwen.yu@icfo.es
Mr.	Vahagn	Mkhitarian	Armenia	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	vahagn.mkhitarian@icfo.es
Mr.	Pablo	De Roque	Spain	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	pablo.deroque@icfo.es
Mr.	Valeria	Rodríguez	Colombia	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	valeria.rodriguez@icfo.es
Dr.	Johann Michel	Berthelot	France	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	johann.berthelot@icfo.es
Dr.	Óscar	Vázquez	Mexico	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	oscar.vazquez@icfo.es
Prof.	Maciej Andrzej	Lewenstein	Poland	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	maciej.lewenstein@icfo.es
Dr.	Ilaria	Mannelli	Italy	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	ilaria.mannelli@icfo.es
Mrs.	Lara	Laparra	Spain	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	lara.laparra@icfo.es
Dr.	Matz	Liebel	Germany	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	matz.liebel@icfo.es
Mr.	Roland	Terborg	Germany	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	roland.terborg@icfo.es
Dr.	Jordi	Gomis-Bresco	Spain	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	jordi.gomis@icfo.es
Mr.	Alexander	Block	Germany	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	alexander.block@icfo.es
Mr.	Kutlu	Kutluer	Turkey	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	kutlu.kutluer@icfo.es
Dr.	Sylwester	Gawinkowski	Poland	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	sylwester.gawinkowski@icfo.es
Dr.	Soledad	Royo	Spain	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	soledad.royo@icfo.es
Dr.	Christine	Payne	USA	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	christine.payne@icfo.es
Dr.	Claude	Renaut	France	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	clauderena@icfo.es
Mr.	Vikas	Remesh	India	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	vikas.remesh@icfo.es



Dr.	Daniel	Andrén	Sweden	Male	Maskingränd 2	41296	Gothenburg	Sweden	Chalmers University of Technology	daniel.j.andren@gmail.com
Dr.	Srdjan	Acimovic	Serbia Montenegro	Male	Maskingränd 2	41296	Gothenburg	Sweden	Chalmers University of Technology	srdjan.acimovic@chalmers.se
Mr.	Juan Miguel	Pérez	Venezuela	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	juan-miguel.perez@icfo.es
Mr.	José	Martínez	Spain	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	jose.martinez@icfo.es
Mrs.	Lisa	Saemisch	Germany	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	lisa.saemisch@icfo.es
Dr.	Jaime	Ortega	Mexico	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	Jaime.Ortega@icfo.es
Mrs.	Rafael	Sibilo	Netherlands	Female	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	rafael.sibilo@icfo.es
Mr.	Anshuman	Singh	India	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	anshuman.singh@icfo.es
Mr.	Mustafa	Gündogan	Turkey	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	mustafa.gundogan@icfo.es
Mr.	Nicola	Palombo	Italy	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	Nicola.Palombo@icfo.es
Dr.	James Tom	Hugall	United Kingdom	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	james.hugall@icfo.es
Dr.	Richard	Lane	United Kingdom	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	richard.lane@icfo.es
Dr.	Nitin	Mohan	India	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	Nitin.Mohan@icfo.es
Mr.	Rinu Abraham	Maniyara	India	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	rinu.maniyara@icfo.es
Dr.	Davide	Janner	Italy	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	davide.janner@icfo.es
Dr.	Mikael	Svedendahl	Sweden	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	mikael.svedendahl@icfo.es
Dr.	Felix	Campelo	Spain	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	felix.campelo@icfo.es
Mr.	José	García	Spain	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	jose.garcia@icfo.es
Dr.	Erik Thomas	Garbacik	USA	Male	Av. Carl Friedrich Gauss, 3	08860	Castelldefels	Spain	ICFO	Erik.Garbacik@icfo.es