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science stories

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European Science Stories

Dear Reader

Agatha Keller, Christoph Hock, Sofia Karakostas and Detlef Günther.

The full re-association of Switzerland to Horizon 2020, the biggest EU Research and Innovation programme ever, is a major relief and an important milestone for us. The benefits are manifold and go far beyond the obvious financial aspects. Our researchers can again collaborate and compete equally with their peers for the best and most innovative research ideas, the highest impact for society and the most elaborate training programmes. Although challenging, this continuous benchmarking is one of the driving forces of improvement and thereby significantly contributes to scientific excellence. This principle is not unique to Horizon 2020 but is also true for funding programmes that receive less public attention, but nevertheless play a crucial role for scientific success stories – be it by covering a niche, by complementing other funding instruments or by enabling collaborations beyond Europe. In this issue, we introduce you to three scientists, three stories, and three funding instruments.

The development of a new transistor technology by Professor Colombo Bolognesi and his team at the Millimeter-Wave Electronics Laboratory has been a key contribution of ETH Zurich to recent projects of the European Space Agency (ESA) such as "Rosetta" and will play a crucial role in future space missions. The newly developed Indium Phosphide High Electron Mobility Transistors enable the amplification of extremely weak signals that are sent back to earth from deep space missions. This achievement as well as the related spin-off company DIRAMICS have received financial support through ESA.

The research of Fritjof Helmchen, Professor of Neuroscience at the University of Zurich and holder of a prestigious ERC Advanced Grant, is mainly about developing and improving tools to visualise the brain at work and to apply them to enhance our understanding of the complex interactions of different brain areas during the processing of sensory input and encoding appropriate behavioural output. He is one of the few holders of a main award of the US National Institutes of Health (NIH) in Zurich. This grant enables his research team to be part of the large NIH BRAIN Initiative and to expand the personal and professional overseas network .

Needless to say that international collaboration and networks are also key elements for the research area of Professor Nina Buchmann. As an ETH Professor of Grassland Sciences, she investigates the influence of agriculture and forestry on environment and climate change, hence a topic of worldwide relevance and importance. In this context, Actions of the European Cooperation in Science and Technology (COST) are a useful frame for networking by means of financial support for workshops, conferences and travel that complements funding of international collaborations through grants from Horizon 2020. Such a combination of structural and thematic funding is ideally suited to foster emerging talents.

Applying for competitive third party funds is an integral part of a scientist's daily work. While the current EU Framework Programme Horizon 2020 often plays the most important role in international public funding, other tailor-made programmes should be considered as well for covering specific needs. Some of them are presented here and we are convinced that these successful Science Stories will broaden your funding perspectives beyond the current horizon. Enjoy reading.

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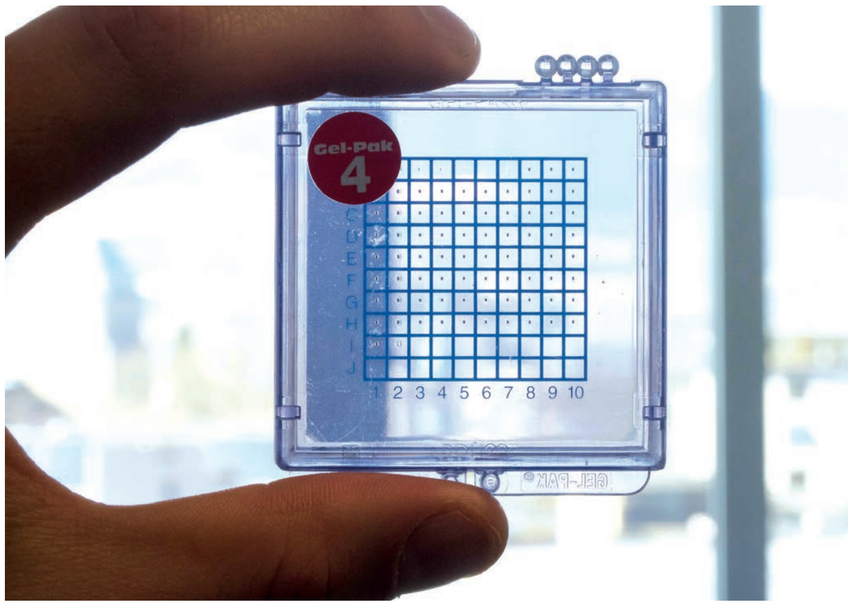
Cover: Two-photon microscope image of pyramidal neurons in layer 2/3 of mouse neocortex expressing a fluorescent calcium indicator.
(courtesy of A. van der Bourg, J. Chen, F. Voigt, and F. Helmchen)



Reaching for the stars

Harvesting data from ESA deep space missions

Why Colombo Bolognesi's transistors play a crucial role for ESA and why he is so passionate about building semiconductors.

There was great enthusiasm and relief among the Rosetta Mission team at the ESA Operations Centre in Darmstadt on this Friday morning, 12th November 2014. The European Space Agency ESA's Rosetta spacecraft had just successfully deployed the Philae lander to the surface of the 67P/Churyumov-Gerasimenko comet.

«I would not have initiated work on this type of semiconductor if ESA had not asked me to.»

During the months to follow, Rosetta would transmit thousands of radio messages back to Earth carrying masses of data collected by Philae and the orbiter. More happy faces were seen that morning at ETH Zurich in the team of Colombo Bolognesi, Professor of Millimeter-Wave Electronics. He and his group had designed and fabricated the semiconductor components, which amplified the very weak radio signals reaching the Earth from Rosetta and other space missions, making the data contained available for scientific analysis. Without such tiny highly refined devices, cooled to –258°C and operating at the heart of ESA ground stations antennas, earthbound scientists could access neither their experimental results nor the output of scientific imagers.

Building transistors – a fascinating task

"When I visit the ESA website and consider the pictures originating from various missions, I have a sense of accomplishment thinking the bits making up these amazing images went through our devices!", Colombo Bolognesi says with laughter when we meet him on a spring morning in his spartan but disco ball-equipped ETH Zurich office. Transistor technology has fascinated Colombo Bolognesi since he was an engineering student, and this passion still drives him today. "The amazing thing is you can substitute just a few atoms here and there to achieve marked changes in device performance. We know the properties of certain materials well enough so that we can engineer tailor-made devices for specific applications by "alloying" or mixing these materials in specific proportions. This gives me a lot of satisfaction", he says. "Building" a semiconductor on the atomic layer level is a fascinating process that tests one's understanding and control of nature and requires working in a cleanroom laboratory with highly specialised tools. The device engineers deposit layer upon layer of crystals consisting of selected elements to form an atomic layer stack with the desired characteristics. Crystalline layers are deposited on indium phosphide wafers from which chips can eventually be cut off. Essentially, the periodic table of the elements forms the alchemist's toolbox with which Colombo Bolognesi and his PhD students create novel semiconductors.

As our daily lives become increasingly digitised, the demand for novel higher performance semiconductors grows continuously. Faster internet services, self-driving cars or even high-resolution movies on smart phones rely on the swift wireless

2 / image by ESA
3 / image by Olivier Ostinelli

transmission of ever-increasing masses of data. Such high-speed wireless networks represent a more down-to-earth application for the type of semiconductors Colombo Bolognesi is developing. In the years past, he and his team have focused their research mainly on the production of high-speed transistors based on certain material systems involving phosphide and nitride compounds (InP, AlGaN). It was exactly this kind of InP-based semiconductors (specifically, high-speed low-noise "High Electron Mobility Transistors" or "HEMTs") which was used by ESA to amplify radio signals from different remote spacecraft missions such as Rosetta.

Cooperation with ESA –a challenging partnership

Colombo Bolognesi's cooperation with ESA began some ten years ago, when he was appointed Full Professor at ETH Zurich. ESA inquired if he would continue a cooperation established by his predecessor to develop a new generation HEMT built on indium phosphide (InP). Colombo Bolognesi agreed. He had dreamed of working with this technology already as a PhD student some 20 years before, and he seized the opportunity to enter this research field. Cooperation with ESA is quite special: Researchers like Colombo Bolognesi are considered contractors. ESA issues a call for tenders; researchers or companies submit their bids including a compliance matrix addressing ESA's specifications. They have to indicate in detail which specifications they can fulfil and which will not be met.

«The ultra-low noise transistor technology developed by your group played a key role in recovering scientific data and gave Europe independency on a technology not available elsewhere due to ITAR export control.»
Dr. Klaus-Jürgen Schulz, Head of the ESA Ground Stations Engineering Division.

ESA then selects with whom they will cooperate as primary contractor. Additional participants might also be invited to act as sub-contractors. ESA projects usually last two to three years marked by milestones where the contractors have to deliver definite results. Funds are paid in instalments when milestones are delivered. The typical envelope for such ESA projects amounts to 250,000 Euros and covers the salary of the PhD students as well as material and lab costs.

The European Space Agency ESA's

mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. ESA consists of 22 member states, including Switzerland. By coordinating the financial and intellectual resources of its members it can undertake programmes and activities far beyond the scope of a single European country. ESA`s job is to draw up the entire European space programme and carry it through.
http://www.esa.int/ESA

The Swiss Space Office

is located at the State Secretariat of Education, Research and Innovation SERI. It coordinates Swiss space affairs and acts as a gateway to ESA project funding in Switzerland.
https://www.sbfi.admin.ch/sbfi/en/home/topics/space.html

ESA BIC Switzerland

is one of ESA's 16 European Business Incubation Centres supporting selected entrepreneurs with comprehensive commercial and technical assistance to help them start up businesses that apply space technology to non-space industrial, scientific and commercial fields. It was opened in 2016 and is managed by ETH Zurich, in collaboration with the Institut für Jungunternehmen IFJ, Impact Hub Zurich and the Ambassador Platform of the European Space Agency's ARTES Applications programmes, AP Swiss.
http://esabic.ch/

image by Rickard Lövblom

This is not much compared to the resources researchers can receive from research agencies like the Swiss National Science Foundation or the Horizon 2020 Programme of the European Union. So what are the benefits when cooperating with ESA? Colombo Bolognesi's answer is surprising but quite convincing: "One of the main benefits is that I would not have initiated work on this type of semiconductor if ESA had not asked me to.

«A tiny group consisting of a professor, two scientific employees and two PhD students can compete with major aerospace corporations.»

As an engineer, I prefer working on things with real applications and I am less interested in doing research just for the sake of publications. So the ESA invitation to build a novel transistor offered a great opportunity for meaningful work: ESA deep space network applications have the most demanding performance requirements for semiconductors, and as the ultimate "system integrator" ESA put me in touch with top-level technology end users, in this case radio astronomers in Spain. Had I started this research just on my own, aiming to produce competitive transistors of this type, I could not even have tested them on the level astronomers need to fulfil their requirements. ESA created this opportunity."

Securing European independency

Since 2005, Colombo Bolognesi was involved in four ESA projects, designing, developing and perfecting his HEMTs. They are used to amplify the signals from several ESA as well as NASA deep space missions like Mars Express, Venus Express, Planck Herschel or Rosetta. In the meantime, his team's work came to be highly regarded by radio astronomers and by ESA itself. In a letter of appreciation Klaus-Jürgen Schulz, Head of the ESA Ground Stations Engineering Division, wrote: "The ultra-low noise transistor technology developed by your group … played a key role in recovering scientific data and gave Europe independency on a technology not available elsewhere due to ITAR export control." In fact, such transistors historically cannot be bought easily on the world market as they are subject to the U.S. International Traffic in Arms Regulation. This motivated Colombo Bolognesi and a couple of his students to found the start-up DIRAMICS (http://diramics.com/) with support of the ESA Business Incubation Centre ESA BIC Switzerland. The company will commercialise a decade's worth of developments in low-noise transistor technology achieved through cooperation with ESA. DIRAMICS designs and builds discrete transistors or complete customised low-noise amplifiers. The small spin-off will compete with major U.S. aerospace corporations. It has already begun to sell chips, even to some American companies.

«I prefer working on things with real applications and I am less interested in doing research just for the sake of publications.»

As an engineer, Colombo Bolognesi pragmatically targets useful applications for his technologies. However, at the same time, he has clear ideas on the type of research that makes sense for him: "As engineers, our devices help make the internet faster, sometimes enabling worthwhile applications like tele-medicine. But do we really need a faster internet to watch movies on the train? When I develop semiconductors for ESA, I contribute to our understanding of the universe. I don't grasp all the science behind the data our transistors help to harvest. But gazing at images from worlds that we could only dream of seeing before is both truly humbling and rewarding!".

● Rolf Probala

Interview clip:
www.grantsaccess.ethz.ch/en/sciencestories

Colombo Bolognesi

studied Electrical Engineering at the McGill University in Montreal, Canada, graduating with a Bachelor in Electrical Engineering in 1987, followed by a Master Degree in Electrical Engineering from Carleton University Ottawa in 1989. He continued his studies in the USA at the University of California, Santa Barbara, where he gained a PhD in Electrical Engineering in 1994. He then worked as a BiCMOS Process Integration Engineer for Nortel for one year. In 1995, he became Professor for Engineering Science and Physics at Simon Fraser University Burnaby, Canada, and remained in this position until 2006 when he was nominated Full Professor of Millimeter-Wave Electronics at ETH Zurich.

Greenhouse gas measurement station at Alp Weissenstein/Crap Alv. (image by Dr. Lutz Merbold)

Agriculture: The driven and the driver of climate change

Flux measurements help to develop realistic climate models

Why the type of agriculture has a major influence on the environment and why Nina Buchmann's research deals with two sides of the same coin.

Nina Buchmann's work focuses on the effects of different forms of cultivation on climate and biological diversity and, conversely, on the reactions to climate change of ecosystems, plants and soils. The scientist's rapid speech is impressive; she talks in dense sentences and without interruption. It quickly becomes evident that this researcher is not the dawdling type. Proof thereof are her comprehensive list of publications and the many international projects she is either actively involved in or has initiated herself, for example a multiannual COST Action, a programme aimed at promoting the European cooperation between researchers. In addition, Nina Buchmann heads ETH Zurich and Eawag's competence centre „World Food System Center" consisting of 39 professors, which she co-founded in 2011. Walking with her through the lab and the workshop,

she amazes you by explaining the individual technical components of the isotope mass spectrometer named E.A. Burns, whose one hundred thousandth analysis was recently celebrated by holding a wine reception for the entire team.

«Forests may change from being a CO_2 sink to becoming a CO_2 source and subsequently accelerate climate change even further.»

One is tempted to wonder whether this bustling scientist does still have a personal life. „My husband is asking the same question," Nina Buchmann replies with a laugh, „but I am enthusiastic about my work. I am doing exactly what I have always wanted to do."

Nina Buchmann

Nina Buchmann received her PhD degree in Plant Ecology in 1993. During her three years as an Alexander von Humboldt Fellow at the University of Utah (USA), she worked on stable isotopes. She finished her habilitation in botany at the University of Bayreuth in 1999. Since 2003, Nina Buchmann is Full Professor of Grassland Sciences at the Institute of Agricultural Sciences at ETH Zurich. Since 2012, she serves as Deputy Head of the Department of Environmental Systems Science. The researcher has already published over 215 peer-reviewed papers as well as 26 books and book chapters. Nina Buchmann is and has been involved in several international collaborative projects funded by the current and previous European Framework Programmes. Her dedication to promote young talents is also reflected by the four Marie Curie Individual Fellowships that she supervised. Switzerland is fully associated to the current European Framework Programme Horizon 2020. It is structured in the three main pillars "Excellent Science", "Industrial Leadership" and "Societal Challenges" (http://ec.europa.eu/programmes/horizon2020/h2020-sections).

The effects of climate change on ecosystems

This is not entirely true. Nina Buchmann had set out to become a librarian and enrolled in humanities during her last years at high school. Today, the plant ecologist is a Full Professor of Grassland Sciences at the Institute of Agricultural Sciences at ETH Zurich and is dealing with a topic that is most urgent for us today and the generations to follow: Buchmann analyses the influence of agriculture and forestry on environment and climate and how global warming affects our forests, soils, as well as wild and crop plants. To this end, together with her team, she measures the greenhouse gas exchange between atmosphere and ecosystem at six different locations in Switzerland. They analyse whether forests, grasslands and croplands are able to absorb and store harmful greenhouse gases or, on the contrary, whether they emit greenhouse gases, e.g. due to intense agricultural soil cultivation.

The team uses innovative infrared gas analysers and laser spectrometers to measure twenty times per second the concentration of carbon dioxide (CO_2) above the mixed woodlands on top of the Lägeren, the small ridge between Baden and Dielsdorf, because trees play a major role in the absorption and storage of CO_2.

Spruce could fall victim to climate change

Ever since 1997, the CO_2 exchange has been measured in a spruce forest near Davos at an altitude of 1,600 meters above sea level. The data of the past 20 years have shown that the forest has always been a CO_2 sink, even during the extraordinarily hot summer of 2003. However, according to Nina Buchmann, the question is whether this characteristic remains unchanged when conditions become increasingly warm and dry caused by global warming. Forecasts predict that by 2050 precipitation in the summer will have decreased by approximately 20 percent, the temperatures being two degrees higher than today.

«The COST Action was a great experience because the participants met on a regular basis to discuss contents and receive valuable inputs.»

When it is dry and warm, trees reduce their transpiration and therefore photosynthesis, during which they absorb CO_2 from the air, and they also respire more CO_2. Forests may thus change from being a CO_2 sink to becoming a CO_2 source and subsequently accelerate climate change even further. Spruce, also called the ‚Brotbaum (high-yield tree) of European forestry' because this fast-growing conifer has been a favoured building timber for the past centuries, could „fall victim to the climate change," as Nina Buchmann fears. Spruce can live up to 600 years; however, air pollutants are afflicting it already today in many regions and the increasing periods of drought and higher temperatures make it difficult for the tree with its shallow root system to take up enough water.

The CO_2 flux measurements in the Davos spruce forest started out as an individual project; however, they soon became part of many EU projects and are therefore integrated into a vast network, for example as part of the ICOS-CH project headed by Nina Buchmann. It forms part of the European ICOS RI (Integrated Carbon Observation System Research Infrastructure), a project of the European Strategy Forum on Research Infrastructures (ESFRI). Nina Buchmann explains the importance of the international data exchange for the validation of the greenhouse gas balance throughout Europe and for the discussion of specific problems. For example, her team constantly exchanges the spruce forest data with the pinewood data of Finnish researchers. She actively uses the networking opportunities available. In her opinion, the international exchange regarding techniques, measurement data, equipment as well as results is indispensable.

This global communication is also supported by COST projects. Nina Buchmann herself headed a COST Action during roughly five years; researchers from more than 20 European countries as well as from Australia participated in this venture entitled „Stable Isotopes in Biosphere-Atmosphere-Earth System Science". „It was a great experience because the participants met on a regular basis to discuss contents and receive valuable inputs." she recalls.

Ploughed grassland is a major source of nitrous oxide

Researchers from other countries, too, examine the reasons behind what enables or destroys carbon reservoirs. However, since 2012, Nina Buchmann and her team also conduct flux measurements of methane (CH_4) and nitrous oxide (N_2O) above grasslands. „When we published the first results for a grassland site in 2014, our colleagues from abroad asked sceptically what exactly it was that we were measuring … and then they started getting anxious," she remembers.

With good reason, as it turned out: The measurements clearly showed that a freshly ploughed grassland sowed with new plants and fertilised with farmyard manure acted as a bubbling source of N_2O throughout the entire first year. The high level of the N_2O emission had not been measured before … and never again since then, either. Grassland serves as fodder for ruminants and was so far considered a small greenhouse gas sink. No one had ever performed measurements during the year of breaking when the farmers plough the entire area and sow it anew, which happens about every seven to ten years. Besides, the recently ploughed soil and the upheaved farmyard manure emit great amounts of CO_2, more than the regrowing vegetation is able to absorb. The extraordinarily high CO_2 emission during that one breaking year neutralises about five years of carbon sink. The team could not believe the results either. „At first, we doubted the proper functioning of the equipment," Nina Buchmann says. However, the measuring instruments performed accurately.

Agriculture adds significantly to climate change

After CO_2, CH_4 and N_2O are the most important greenhouse gases caused by human activities. The atmospheric life of N_2O (approximately 114 years) is almost the same as the one of CO_2, but it is only present in small traces – yet it is three hundred times as effective as CO_2. CH_4 does not remain in the atmosphere as long as CO_2 but it is twenty-five times more effective. CH_4 and N_2O are mainly released by agricultural practices, for example by spreading nitrogenous manure (N_2O) or by keeping farm animals (CH_4; the fermentation of fodder inside the digestive system of ruminants).

«Once you are actively involved and know many people, the interesting projects are easier to attain.»

Nina Buchmann states that global agriculture contributes between 10 and 12 percent to climate change. Switzerland's agricultural contribution amounts to 13 to 14 percent. Hence, agriculture is both a driving and a driven element of climate change. According to Nina Buchmann, the flux measurements are all the more important as they help to develop realistic climate models and enable more accurate estimations of the climate change's effects. Since 2014, her team measures the absorption and emission of N_2O and CH_4 in the spruce forest near Davos. First results point to the fact that the forest currently neither emits great amounts of these greenhouse gases to the atmosphere nor does it absorb much of them either.

Diversity: more stable, resistant and high-yielding grasslands

The top-class members of the „World Food System Center" headed by Nina Buchmann are among the researchers who devote themselves to defining the type of agriculture that is most

sustainable for the environment and at the same time sufficiently high-yielding to feed the world's growing population. The data acquired by the centre, in turn, serve as a basis for Switzerland's Federal Office for Agriculture's national agricultural policies.

«The measurements showed that a freshly ploughed grassland sowed with new plants and fertilised with farmyard manure acted as a bubbling source of N_2O.»

Different types of cultivation have varying effects on climate change. However, also the fields of conventional farmers could be carbon-neutral were they to repeatedly apply organic fertiliser (for example liquid manure) instead of merely synthetic fertiliser. This, too, was revealed by the studies, says Nina Buchmann. The most important aspect is that the farmer keeps an eye on soil fertility, as a fertile soil has a large carbon stock, which not only contributes to a greenhouse gas sink in the long run but also secures a constant harvest.

Since 15 years Nina Buchmann participates in an international long-term project that analyses the effects of an ample plant diversity compared to a monoculture in grasslands. It turns out that plots with high biodiversity (up to 60 different species) are more stable against alien species and more resistant in harsh weather conditions; and, what is more, they are also more high-yielding.

Since her younger years as a student, Nina Buchmann has had global connections. Her doctorate supervisor sent her to conferences early on and she served as his representative at meetings. „Once you are actively involved and know many people, the interesting projects are easier to attain," as she quickly discovered. One of the reasons for her unabated enthusiasm is the international exchange, be it by means of COST networking Actions or the European Framework Programme Horizon 2020: „Advancement is only possible through international exchange and competition is vital to increasing our creativity." When Nina Buchmann was a PhD candidate, she already knew what to target in order to reach her goal. „I asked my doctorate supervisor: ‚How do I become a professor?'" Today, she sends her ‚youngsters', as she calls her PhD candidates, to international workshops and conferences. „Now it is their time to make their marks."

● Denise Battaglia

Interview clip:
www.grantsaccess.ethz.ch/en/sciencestories

COST

Actions of the European Cooperation in Science and Technology (COST) promote the networking and exchange of researchers by means of workshop, conference and travel funding. Researchers may participate in already existing Actions or launch their own ventures (http://www.cost.eu/COST_Actions). COST Actions are often the beginning of successful future European research projects. Since 2017, the Swiss National Science Foundation is in charge of all operational tasks of COST in Switzerland (http://www.snf.ch/en/funding/programmes/cost/Pages/default.aspx). EU GrantsAccess supports researchers with all the relevant information on open calls and is an important partner throughout the application phase.

Observing the brain at work

An interview with Fritjof Helmchen, Professor of Neuroscience at the University of Zurich

What Fritjof Helmchen detects when he observes living brains in action, what he dreams of and how he managed to become part of the NIH BRAIN Initiative.

Fritjof Helmchen, how did you become a neuroscientist?

From an early stage, I was fascinated by complex systems and when I got the chance to step into neuroscience looking at the brain as THE most complex system I was just captured. I started as a physics student but very quickly became interested in biophysics and neuroscience. At that time, I also decided to study medicine in parallel to physics. Finally, I got my PhD in physics for neuroscientific work and completed the basic examinations in human medicine as well. I have stayed in neuroscience since then.

You have been in this field for many years. How would you describe the core of your research?

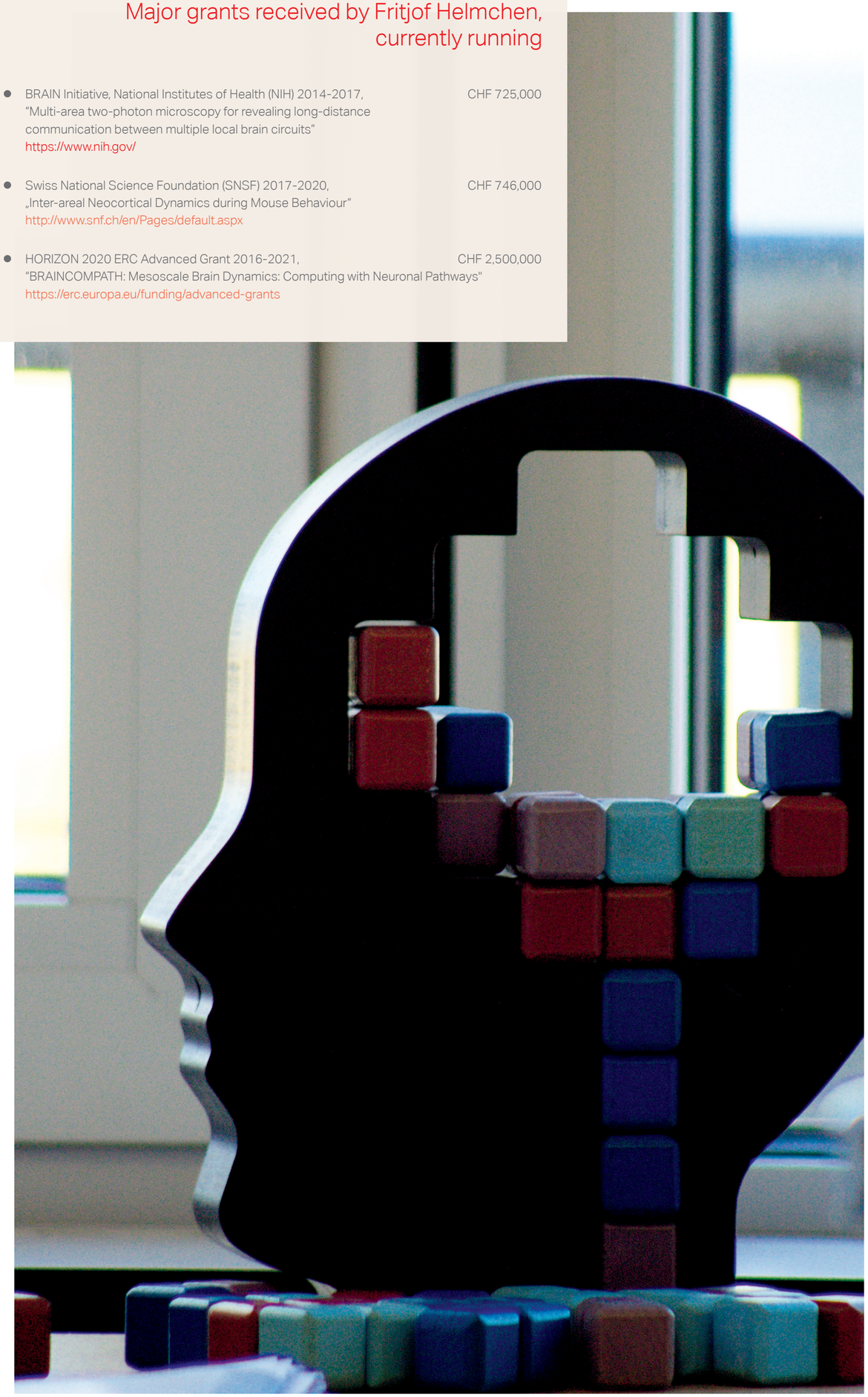
My research over the last 20 years has covered mainly two fields. On one hand, I have focused on the development of new microscopy tools and optical methods to record and visualise the activity of neurons and populations of neurons in the brain under in vivo conditions, i.e. in the living animal. On the other hand, I have been applying these tools to investigate what happens in the brain of a behaving animal, for example when it responds to sensory stimuli. The brain is a device that takes in all the information from the sensory organs and processes them in a suitable way to generate an appropriate behaviour for the interaction with the outside world. This process involves many brain areas, in mammals especially the neocortex. We want to understand how signals flow in the network of brain regions to trigger a specific behaviour. Moreover, we also want to find out what happens during learning when the brain adapts to new situations and the network has to reorganise itself. As a key method, we apply two-photon microscopy, which enables us to watch neurons in vivo while the animal performs its behaviour. In other words, we observe the brain at work.

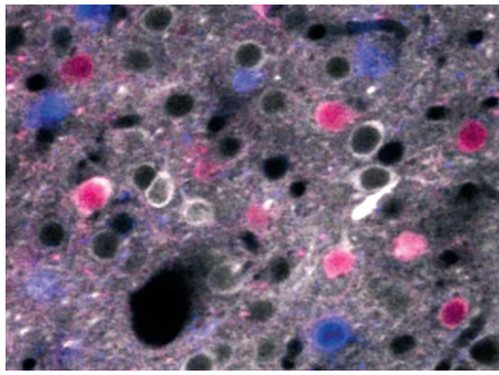
Measure neuronal activity in the brain in vivo

The major research interest of Fritjof Helmchen is to reveal fundamental principles of neural circuit function with regard to brain computations and learning by advancing optical methods for studying neuronal network dynamics 'in vivo', which means in the living brain at work. For this research, he particularly applies two-photon microscopy, a special fluorescence microscopy technique that allows direct observation of neuronal activity patterns in vivo. A small glass window that replaces a part of the skull of the mouse makes it possible to watch and measure with the microscope what happens in the brain while the mouse follows its normal activities or performs trained behaviours. Fritjof Helmchen's group has pioneered several two-photon microscopy variants, including 3D and high-speed in vivo two-photon imaging, and has contributed to recent advancements in the study of brain microcircuits.

Major grants received by Fritjof Helmchen, currently running

- BRAIN Initiative, National Institutes of Health (NIH) 2014-2017, CHF 725,000
  "Multi-area two-photon microscopy for revealing long-distance communication between multiple local brain circuits"
  https://www.nih.gov/
- Swiss National Science Foundation (SNSF) 2017-2020, CHF 746,000
  „Inter-areal Neocortical Dynamics during Mouse Behaviour"
  http://www.snf.ch/en/Pages/default.aspx
- HORIZON 2020 ERC Advanced Grant 2016-2021, CHF 2,500,000
  "BRAINCOMPATH: Mesoscale Brain Dynamics: Computing with Neuronal Pathways"
  https://erc.europa.eu/funding/advanced-grants





In vivo two-photon microscope image of cortical neurons that express a genetically-encoded calcium indicator. Two subtypes of neurons that project to distinct brain areas are additionally labelled in two different colors. The cell bodies have about 15 microns diameter. (Courtesy: J. Chen, F. Helmchen)

What is your conclusion from these experiments?

One conclusion is that we see things happening at many places in the brain. Information processing is not merely taking place locally but in a distributed fashion so that many areas of the brain are involved. That is why we want to improve experimental techniques to measure simultaneously from multiple brain areas so that we can begin to understand the rules of how they communicate.

Ultimately, what could be the impact for society of your basic research?

Our basic research first fosters a better understanding of normal signal flow in a healthy brain. On this foundation, it may also help to understand what goes wrong when brain networks are in disorder or affected by a disease. For example, brain damage caused by a trauma, a stroke or a degeneration process will lead to adaptive changes in the signal flow in the remaining part of the brain. And there is the whole spectrum of psychiatric disorders, for which the anatomical changes are less obvious. Here, our basic insights regarding brain signal flow could be valuable in order to identify and characterise misguided signal flow in disordered brains. In the end, we hope that our results will contribute to developing therapies to alleviate or cure human brain diseases.

If you as a researcher could make one dream come true – which one would it be?

I have the dream that the current advances in understanding signal processing in the brain will eventually lead to a brain theory that can be expressed in terms of mathematical equations. This theory of brain dynamics would allow us to describe and reproduce the essentials of signal processing and the generation of adaptive behaviour by the brain.

So once you can describe these essentials mathematically, you would be able to build a brain?

The aim would not be to build or replicate an entire brain, but you could perhaps build a simplified device, which would be able to reproduce certain types of high-level cognitive behaviour.

Based on such a brain theory, could you build a robot able to learn like the brain does?

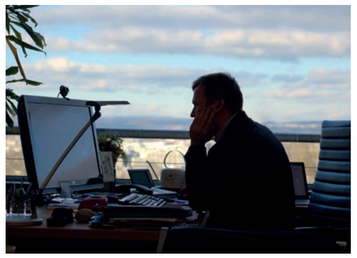
I think so. We are entering a phase where computer science and machine learning approaches, together with the new insights in neurobiology and brain research, are likely to boost the developments in this direction. In the end, it might lead to new devices, which operate based on insights we gained from neuroscience and computer science. New machine learning approaches have been quite successful for instance in pattern recognition. However, as far as I know, they are such complex artificial networks that even the specialists do not understand what is going on. So even they would like to capture the essence and understand the principles of how their machines' deep networks really operate. That is a common challenge regarding biological and artificial neuronal networks in the coming years.

Let us talk about research funding. Three years ago, you applied for a grant of the NIH and you got it. Why?

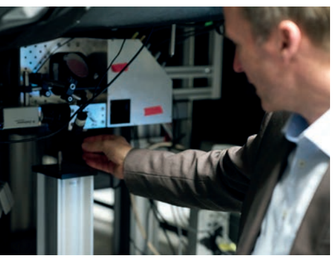
My project financed by the NIH is linked to the US-led BRAIN Initiative that President Obama initiated in 2013. The scope of this initiative is very much aligned with the scope of my own research, which motivated me to apply. The NIH BRAIN Initiative has the same core aspects as my research: pushing forward with neurotechnologies, focusing on the network level and trying to capture the principles of circuit dynamics in the brain. Eventually, the aim is to investigate brain diseases and circuit dysfunctions. So I submitted my application to the NIH as I thought my lab would fit perfectly into their programme and we could benefit from interactions with the US groups. Now we are very happy that for almost three years we have been part of the NIH BRAIN Initiative. Just recently, I applied for an extension of our grant, and I hope very much that it will be approved because we really would like to stay in this programme.

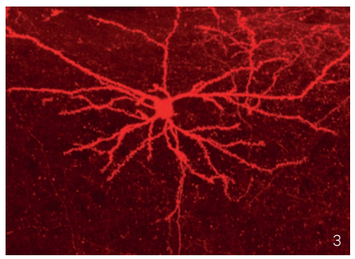
Fritjof Helmchen

Fritjof Helmchen studied physics and medicine (preclinical part) at the University of Heidelberg and received his PhD in physics at the University of Göttingen for work carried out at the Max Planck Institute for Medical Research in Heidelberg. During his postdoctoral period at the Biological Computation Research Department at Bell Laboratories in New Jersey, USA, he helped to establish two-photon microscopy as a novel technology that enables measurements of neuronal activity in the brain in vivo. After his return to Europe, he applied and refined this technology when he led a junior group at the Max Planck Institute in Heidelberg. In 2005, Fritjof Helmchen was appointed Associate Professor of Neurophysiology and Co-Director of the Brain Research Institute at the University of Zurich. Since 2013, he is Full Professor of Neuroscience. He currently acts as Director of the Neuroscience Center Zurich.



3 / Confocal microscope image of a fluorescently labeled pyramidal neuron with its dendritic processes and the descending axon in the upper layer of mouse neocortex. The image was taken from a histological brain section. (Courtesy: J. Chen, L. Sumanovski, F. Helmchen)





3

How was your experience with the NIH?

(Laughing) It was very good as we got funded. However, I must admit that at the beginning I did not expect to have a real chance, being a European lab. I was excited when, in the end, several European labs were included in the funding and became part of the BRAIN Initiative.

Apart from the financial aspect, how do you benefit from this NIH grant?

A key benefit is the extra level of scientific networking. Progress in research depends largely on the interactions with other scientists. Ideas are usually not generated when you sit in a quiet room but through discussions with other researchers. So the opportunity to participate in important meetings like the annual conference of the BRAIN Initiative is crucial to catch up with the latest trends in the field and cutting-edge methods. You can then select what you want to use in your own lab and in which direction you want to proceed. That is even more valuable than money.

So would you recommend other researchers to apply for a grant at NIH?

Yes, definitely. Many researchers in Europe do not know that for some of the NIH grants European labs are also eligible. Therefore, I can only encourage people to try.

You have funds from several agencies at your disposal. You received an ERC and SNSF Grant. Do you follow a specific funding strategy?

In addition to the core funding of my university, I was fortunate to be well funded over the years by different funding agencies; first of all by the SNSF, which was very important to me. But another important pillar of finance have been the EU research funds. Before I received the ERC Grant, I participated in several EU research consortia where I got to know many colleagues. I also learnt a lot about other labs and institutions in Europe and could form scientific collaborations. Nevertheless, there is no real strategic concept behind my grant applications beside the research direction and the specific interests at the given moment, which obviously change over the years.

Comparing these funding agencies, what are the main differences?

One of the differences between the several agencies relates to the bureaucratic requirements and administrative burdens associated with them. For me as a researcher this is a crucial point, as time spent on administration matters is time lost doing research. That is why my colleagues and I like lean administration. Unfortunately, the EU research administration is particularly bureaucratic. But also the administrative processes for the NIH grant have been quite complicated. Therefore, a service like that of EU GrantsAccess is of great help. I have to emphasise that for both grant applications, to the NIH and the ERC, the EU GrantsAccess Office was very helpful in setting up and handling the application, supporting us throughout the entire procedure.

Based on your experience, what would you recommend your colleagues regarding funding applications?

First, I would recommend to just 'try it', even if it is an effort. Writing an application for a grant is also an opportunity to think about your concept and to put your ideas down on paper. Even if your application is rejected, your effort was not in vain. The work you have done has helped you to refine your research focus and you might use the application for another funding scheme. However, to be successful I also recommend defining your own niche where you have your unique brand of excellence. You know the field, you know the other research groups, you know where your place is in the field and you know the unique expertise of your research team. Build upon these strengths for a grant application and make a strong case for what you can contribute.

● Rolf Probala

Interview clip:
www.grantsaccess.ethz.ch/en/sciencestories

Ten years of US federal sponsored research

Participating in US federal sponsored research is a complex affair. First, organisations must be centrally registered in at least five different US systems to allow their researchers to submit proposals to US federal funders. EU GrantsAccess has installed and maintains all necessary registrations for both the University of Zurich and ETH Zurich (e.g. DUNS, eRA commons, NCAGE, grants.gov, SAM etc.). We also constantly update all required organisational certifications and assurances to allow researchers to conduct projects including animal and human subjects in research sponsored by US federal dollars (Federalwide Assurance, Institutional Review Board registration, Animal Welfare Assurance). Over the last ten years, we acquired significant knowledge about US federal regulations. Consequently, we implemented institutional policies and processes to ensure compliance and to minimise and mitigate the risks for researchers and institutions. A close collaboration with our internal partners at financial and legal services and in the departments/faculties was key to enable successfully the support and service level we are able to provide at this stage.

In order to keep up to date with the ever changing US regulations and requirements we are active in various international networks such as the National Council of University Research Administrators (NCURA), the European Association of Research Managers and Administrators (EARMA) and Universitas 21. Naturally, we also rely on your feedback to improve and facilitate our support further, so that in the end, you can do what you like most: science and research with low administrative burden.

Curious about open US funding opportunities?
Visit https://www.grants.gov/web/grants/search-grants.html or make an appointment with one of our specialists.

Your EU GrantsAccess Team

EU GrantsAccess will gladly support and guide you through the application process for all international grants.

Contact: www.grantsaccess.ethz.ch

The US Expert Group

EU GrantsAccess' US Expert Group supports researchers from the University of Zurich and ETH Zurich in submitting and managing grants and contracts from US federal sponsors. We make sure that policies covering specific US federal regulations are in place and provide tailored personal advice to all researchers applying for or holding US federal projects. The most prevalent US federal grants seen in Zurich are from the National Institutes of Health (NIH), the Air Force Office of Scientific Research (AFOSR) and the Intelligence Advanced Research Projects Activity (IARPA).

Members of the EU GrantsAccess US Expert Group are (from left to right):
Luca Wacker, Annika Glauner, Nicolas Schulthess, Regina Notz (lead) and Karl Kerschbaum.

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