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Dear Reader

European Science Stories

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 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 itself 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 DRAMICS have received financial support through ESA. Why Colombo Bolognesi's transistors play a crucial role for ESA and why he is so passionate about building semiconductors.

The research of Frithjof 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 visualize 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 behavioral 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 useful frameworks 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.

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) 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," says Colombo Bolognesi.

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, worldwide 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 device", 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 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. Crystaline 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 mobile phones rely on the swiftness of
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.


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 Institute for Jungunternehmen (I4J), Impact Hub Zürich and the Ambassador Platform of the European Space Agency’s ARTES Applications programmes, AP Swiss.

http://esabic.ch/
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 just for the sake of research. So 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, 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.”

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!”

Asking with her through the lab and the workshop, it quickly becomes evident that this researcher is not the daedalian 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,
agriculture: the driven and the driver of climate change

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 intensive agricultural soil cultivation.

The team uses innovative infrared gas analysers and laser spectrometers to measure twenty times per second the concentration of carbon dioxide (CO₂) above the mixed woodlands on top of the Lägern, the small ridge between Baden and Dilolzach, because trees play a major role in the absorption and storage of CO₂.

Spruce could fall victim to climate change

Ever since 1997, the CO₂ 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 CO₂ 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 CO₂ from the air, and they also respire more CO₂. Forests may thus change from being a CO₂ sink to becoming a CO₂ source and subsequently accelerate climate change even further. Spruce, also called the ‘Brotbaum (high-yield tree) of European forestry’ because it is suitable for building timber for the past centuries, could “fall by 2050 into a CO₂ source” if climate change makes it impossible for trees to absorb enough water.

Diversity: more stable, resistant

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 (CH₄) and nitrous oxide (N₂O) 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.

“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 CO₂, CH₄ and N₂O in the spruce forest near Davos. First results point to the fact that the forest currently neither emits nor takes up enough water.

Diversity more stable, resistant and high-yielding grasslands

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

The global communication is also supported by COST projects. Nina Buchmann herself headed a COST Action during roughly five years; researchers from more than 30 European countries as well as from Australia participated in this venture entitled “Stable Isotopes in Biogeochemistry - Earth System Sciences”. 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

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Diversity more stable, resistant and high-yielding grasslands

The top-bias 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...
different greenhouse gases. For instance, the production of cement, a major component of construction materials, uses a significant amount of energy. On average, the cement industry accounts for about 8% of global carbon dioxide emissions. This highlights the need for sustainable alternatives and innovations to reduce its environmental impact.

The selection of a suitable cement technology is crucial. One promising approach is the use of carbon capture and storage (CCS) techniques. CCS involves capturing carbon dioxide emissions from industrial processes and storing them underground, thus preventing them from contributing to climate change. This technology not only mitigates the direct emissions from the cement production process but also contributes to long-term greenhouse gas reduction targets.

By combining advanced cement production methods with emission reduction technologies, the industry can significantly reduce its carbon footprint. Moreover, ongoing research and development are focusing on developing low-carbon cements and clinker substitution with alternative materials. These efforts are crucial in the transition towards a more sustainable built environment, protecting future generations from the impacts of climate change.
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 degenerative 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 diseased/traumatized brain areas. 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 will 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 the fundamental principles 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, there are such complex artificial networks that even the specialists do not understand what is going on. So even if 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 had submitted my application to the NIH because I thought my lab would fit perfectly into the 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.

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.

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strategy? SNSF Grant. Do you follow a specific funding process? You received an ERC and have funds from several agencies at your disposal. Y ou received an ERC and have funds from several agencies at your disposal. 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 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 in a grant application and make a strong case for what you can contribute.

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 registries 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 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/grantsearch-grants.html or make an appointment with one of our specialists.

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Contact: www.grantsaccess.ethz.ch

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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 come 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 Reich, Armenia Gauer, Nicolas Schüttler, Regina Nottz (lead) and Karl Kerschbaum.

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 don’t know that for some of the NIH grants, European labs are also eligible. Therefore, I can only encourage people to try.

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