SPRING 2016

GIANT REVIEW

— Exploring Science in Grenoble —

Research

THE DIGITAL REVOLUTION @GIANT

GIANT (Grenoble Innovation for Advanced New Technologies) unites research, higher education and industry on a unique campus to overcome the major challenges of tomorrow.

Founding members: CEA, CNRS, EMBL, ESRF, GEM, ILL, Grenoble INP and UGA.





SIX HUBS FOR EXCELLENCE
in science and academia

Major European Research Facilities

A campus that is unique worldwide in its access to high level equipment used to explore materials and living matter.

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Essential support for research that advances knowledge and enables technological innovation.

Energy

Electrical networks, smart buildings, energy conversion and transfer, carbon-free energy sources and energy storage.

Information Technology

MINATEC: dedicated to innovation and technology transfer in the fields of micro and nanotechnology.

Healthcare

A hub for medical, diagnostic and imaging technology with access to internationally recognized organizations.

Innovation Management

Applied research and new business creation as well as innovation and industrial performance training for managers.

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AWARDS & HONORS

Matteo Bianchini (ILL)
2015 ECS Battery Division Student Research Award

Catherine Picart (Grenoble INP)
ERC Proof of Concept Grant

Alim-Louis Benabib (CEA)
Breakthrough Prize in Life Sciences

Frédéric Saudou (UGA)
Bettencourt Schueller Foundation Scientific Award (Coups d'Élan)

Xavier Blase (CNRS) & Ivan Duchemin (L_Sim/INAC)
Bull - Joseph Fourier Prize

Carole Bernard (GEM)
2015 Redington Prize

Stephen Cusack (EMBL)
Elected to the Fellowship of the Royal Society

Andrew Cairns (ESRF)
Young Scientist Award 2016

French Alternative Energies and Atomic Energy Commission (CEA) • National Center for Scientific Research (CNRS) European Molecular Biology Laboratory (EMBL) • European Synchrotron Radiation Facility (ESRF) • Grenoble Ecole de Management (GEM) • Grenoble INP • Institut Laue-Langevin (ILL) • Université Grenoble Alpes (UGA)

Welcome to the GIANT Review

It is with great pleasure that I share with our readers the second edition of the GIANT review. The GIANT campus was founded on the principle that innovation requires collaboration. In this edition, you will discover our researchers' latest discoveries and success stories.

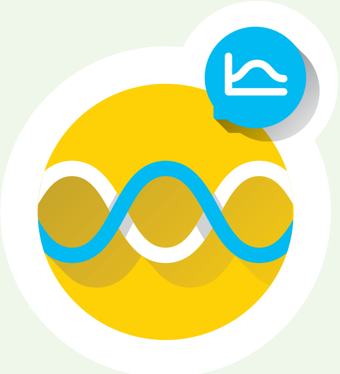
Located in the heart of the Alps, the campus unites eight major institutions to overcome key societal challenges in fields such as energy, health and ICT (Information and Communication Technology). By fostering partnerships between academia, research and business, the GIANT campus brings together 30,000 men and women to innovate for a better tomorrow.

The Grenoble-Alps ecosystem was recently recognized by the national IDEX label for its commitment to collaboration and interdisciplinary research. The IDEX label is awarded by an international jury and provides support for ambitious regional projects that combine research, transfer of technology, education, student life and cultural development.

To further this ambitious vision, the GIANT campus continues to promote the region's international renown as a center for academic and technological excellence. As a result, I am proud to share with you a few of the outstanding results achieved by GIANT community members. From unlocking the secrets of ancient texts (p. 20) to space travel (p. 18), cutting-edge research in biology (p. 8 & 12) or the digital revolution (p. 14), our campus continues to work towards building a better world.

I welcome you to the GIANT campus and hope you enjoy the 2016 GIANT Spring Review.

Brigitte Plateau
President of Grenoble INP



CUTTING-EDGE REFLECTOMETER **READY TO GO ONLINE IN 2016**

The D50 is a unique reflectometer at the Institut Laue-Langevin (ILL) that refracts neutrons through a prism and has the capacity to simultaneously record measurements at different wavelengths. The instrument was specifically designed for ILL industrial applications. Construction was completed in 2015 and the first tests were carried out to demonstrate the effectiveness of the D50's RAINBOW technique when measuring neutron wavelengths. This innovative technique is not only simpler and cheaper than existing techniques, but also more efficient as it uses almost all available neutrons.

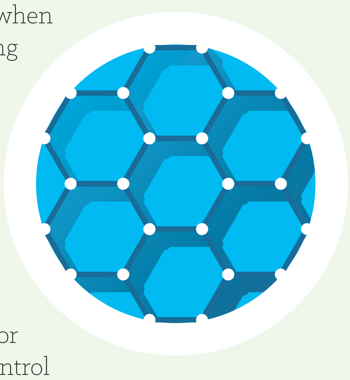
BRISKEE HORIZON 2020 PROJECT:

Studying Household Energy Savings

BRISKEE is a collaborative research project funded by the EU Horizon 2020 research program. Launched in March 2015, the project will last 30 months and study how European households invest in energy saving technology. As a partner institution, researchers from Grenoble Ecole de Management will support this collaborative project by examining how time and risk perceptions influence the returns consumers expect from their energy saving investments (known as the discount rate). Understanding consumer perspectives is essential to help guide future energy policies and investments.

SCIENTISTS EXPOSE ELECTRON-ELECTRON INTERACTIONS IN **GRAPHENE**

As part of the European Union Graphene Flagship program, an international science team, which included researchers from the Université Grenoble Alpes and the CNRS, carried out an experiment to discover the signatures of electron-electron interactions when graphene is subject to a strong magnetic field. The researchers wished to examine this topic because the majority of phenomena studied around graphene have so far been explained without electron-electron interactions. Their discovery proves the presence of such interactions and opens the door to further understanding and control over a fundamental property of graphene.



ESRF SYNCHROTRON SOURCE TO SHINE **BRIGHTER THAN EVER**

After successfully completing phase one of its upgrade program, the European Synchrotron Radiation Facility (ESRF) has launched the ESRF-Extremely Brilliant Source (EBS) project – an ambitious €150 million investment program expected to be completed by 2022. As one of the world's leading radiation facilities, the centerpiece of this upgrade phase will be the delivery of a revolutionary Extremely Brilliant Source to provide unprecedented performance. As Francesco Sette, the ESRF Director General, highlights: "It's a unique and challenging project supported by the ESRF's 21 partner nations. With performances multiplied by 100 in terms of brilliance and coherence, this new source will offer unprecedented tools to explore matter and understand life at a macromolecular level."

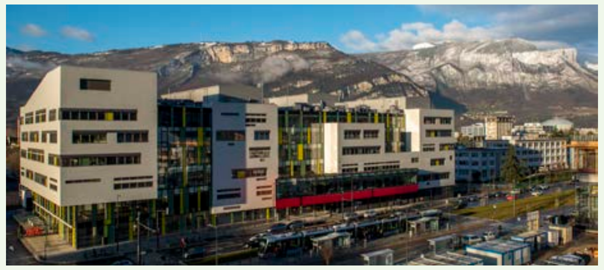
MAKING INNOVATION LAST: A CROSS-DISCIPLINARY CHALLENGE

David Gotteland and Christophe Haon, researchers at Grenoble Ecole de Management, and Hubert Gatignon, a professor at INSEAD, co-authored a comprehensive two-volume book titled Making Innovation Last. The authors' cross-disciplinary approach takes a global look at innovation, which is a key challenge for the long term success of companies. As GIANT and Grenoble Ecole de Management continue to foster innovation, this publication provides managers and researchers alike with a framework to understand and implement conditions which are vital to creating a culture of innovation.

AIRBUS E-FAN PLANE CROSSES ENGLISH CHANNEL WITH **CEA BATTERY TECHNOLOGY**

On July 10th 2015, the all-electric Airbus E-Fan plane successfully crossed the English Channel. The 74 kilometer flight lasted approximately 37 minutes and marked the first time an electric plane took off with its own power and crossed the English Channel. Battery technology is an essential building block to construct electric and hybrid propulsion systems for aircrafts. The CEA-Liten has been actively involved in the development of lithium-ion batteries in partnership with Airbus Defence and Space. The 30kWh battery developed for the E-Fan provides enough energy (180Wh/kg) to ensure the plane's take off and 55 minutes of autonomous flight time.

GREEN-ER: a Smart Building Dedicated to ENERGY RESEARCH AND TEACHING



In September 2015, Grenoble INP - Ense3 opened the doors of the GreEN-ER building, located in the heart of the GIANT campus. Focused on innovation in the fields of energy and sustainable resources, the building represents the city of tomorrow with a yearly energy consumption of less than 110 kWh per square meter. In addition to welcoming students from Grenoble INP and the Université Grenoble Alpes, the building is home to a leading laboratory for innovations in electrical energy (G2Elab) as well as research and teaching platforms (PREDIS and MEE). Part of the building also serves as a "living lab" with hundreds of sensors installed throughout the building for students and researchers to explore energy consumption and discover the innovations of tomorrow.

FD-SOI:
a Competitive Solution
FOR NEXT GENERATION CHIPS

Nanotechnology is a major building block of the GIANT ecosystem with numerous platforms and research labs dedicated to both fundamental research and the transfer of technology. More than 20 years of research at the CEA-Leti has led to the creation and industrialization of Fully Depleted Silicon On Insulator (FD-SOI) technology – Grenoble's answer to meet continuous demands for smaller chips with higher performance and lower energy consumption.

#Information Technology — #Energy — #Health

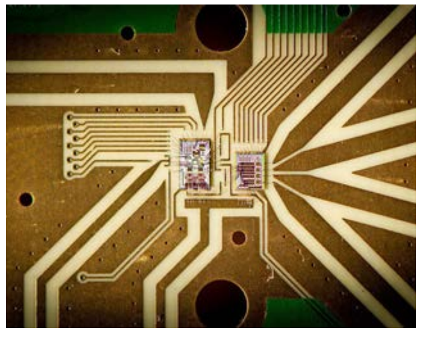
From the Internet of Things and wearables to the automotive or medical industries, better performance and energy efficiency are essential to produce the next generation of digital technology. One of the key challenges of nanotechnology has been to downscale the size of transistors, which are used in chips such as the one in your computer. Current semiconductor chips have been downscaled to the 14 nm limit. However, the process becomes all the more difficult as the industry aims to produce ten nanometer and smaller chips.

BARRIERS TO DOWNSCALING

Traditional methods for producing chips encountered severe difficulties upon reaching the 28 nm limit. *"One of the main issues is that denser chips have a higher proportion of current leakage due to the fact that the more you downscale transistors, the more difficult it becomes to control the flow of current."* explains Thierry Poiroux, a researcher at the CEA-Leti (an institution that was highly involved in the development of FD-SOI technology).

FD-SOI technology makes it possible to produce smaller transistors with lower leakage, and improved performance and energy consumption (see box - FD-SOI Research Focus). *"The technology has demonstrated its capacity to meet demands for technology generations as small as 14 nm, which is the industry's current technological limit. The challenge is to demonstrate the technology's viability for next generation chips."* adds Poiroux.

"Benchmarking studies demonstrate the viability of FD-SOI for ten nanometer chips"



Power amplifier transistor and associated circuit chip for 4G multi-band communication (based on SOI technology)

FD-SOI RESEARCH FOCUS

Creating the right mechanical stress is one of the key challenges to downscaling FD-SOI technology for ten and seven nanometer processes. One of the primary objectives is to create both tensile and compressive strain in local areas within a chip.
The CEA-Leti's latest research demonstrates FD-SOI's ability to solve this challenge through two techniques. The first demonstrates that it is possible to turn unstrained SOI into tensile strained SOI (sSOI) through amorphization and crystallization. The second technique uses the creep of buried oxide (BOX Creep) to achieve sSOI strain relaxation. This makes it possible to create compressive strain as well. These techniques are essential because the two types of transistors in a chip each only respond to either tensile strain (NMOS transistor) or compressive strain (PMOS transistor).

FD-SOI: A SOLUTION FOR TEN AND SEVEN NANOMETER CHIPS?

While the industrialization of FD-SOI technology continues to advance for current generation chips, researchers at the CEA-Leti are already focused on the next two generations. *"Current benchmarking studies have demonstrated that FD-SOI can at least be used for ten nanometer chips. However, as we downscale to the next generation, we must find innovative ways to boost performance."* explains Poiroux.
The CEA-Leti's latest research is focused on increasing performance thanks to new mechanical stress techniques (see box: FD-SOI Research Focus) *"FD-SOI technology relies on planar fabrication processes that are similar to traditional chip fabrication. By proving FD-SOI's viability for next generation chips, we demonstrate that it is possible to achieve considerable performance and energy improvements without switching to more expensive fabrication techniques."* concludes Poiroux. Given the aggressive competition in the field of microprocessors, proving the viability of FD-SOI technology for current and next generation chips is an essential stake for the Grenoble ecosystem.

GIANT EFFECT

"FD-SOI represents more than 20 years of research collaboration. The technology evolved thanks to a regional ecosystem that supported fundamental research, transfer of technology and industrialization. In addition to local players (CEA-Leti, STMicroelectronics and Soitec, among others), FD-SOI is also the result of international collaboration with companies such as IBM, Global Foundries or Samsung. The intersection of research, technology and industry is truly the foundation of the GIANT campus."

THIERRY POIROUX
Researcher at the CEA-Leti

Clean room with Hitachi HCG4000 lithographic machine

Collaborative International Research Opens the Door to New Diagnostic Methods FOR ALZHEIMER'S DISEASE

Researchers at GIANT have discovered an increase in water mobility on the surface of Tau protein fibers. The discovery sheds light on one of the proteins that plays a key role in Alzheimer's and offers hope for new diagnostic methods.

#Energy — #Health — #Large Scale Facilities

The results of research carried out on the GIANT campus and at partner institutions were surprising: *"Our unexpected discovery of increased water mobility on the surface of Tau protein fibers could provide an early stage marker for the diagnosis of Alzheimer's."* highlights Martin Weik, research group leader at the French Institute for Structural Biology (IBS).

SHEDDING LIGHT ON TANGLES

Alzheimer's patients suffer cognitive impairments due to an abundance of plaques and tangles in and around their neurons. Plaques are deposits of a protein called Amyloid beta that interfere with the interaction between neurons while tangles are the accumulation of aggregated Tau protein within nerve cells that eventually destroy the cell. *"Proteins move and wiggle, and water is essential to this movement. We studied surface water mobility on normal Tau proteins and abnormal tangles in order to discover differences in how they operate."* explains Weik.

CRUCIAL ACCESS TO DEUTERATION TECHNIQUES

One of the challenges faced by the researchers was being able to specifically measure surface water dynamics without recording the protein's movement. For this study, the team used a deuteration technique pioneered by the Life Sciences Group at the Institute Laue-Langevin (ILL). The technique replaces the protein's hydrogen atoms with their isotope, deuterium, so that the mobility of hydrogen present in surface water can be singled out.

"The world-class instruments, the Deuteration Lab (D-Lab) and the high flux of neutrons available at the ILL provided researchers with the cutting-edge technology needed to explore the dynamics of their biological samples." says Michael Härtlein, in charge of the D-Lab, a technical platform that is part of the Partnership for Structural Biology (PSB). In addition, he underlines that once a deuteration project is approved by international peer review, the ILL funds the deuteration process. Projects are then carried out in collaboration with staff at the D-Lab.

Martine Moulin, co-author of the publications, prepares deuterated cultures for the Tau protein project.

The deuteration laboratory, which allows scientists in the area of life sciences and structural biology to seek tailor-made deuterated biomolecules.

INCREASED WATER MOBILITY SUGGESTS NEW METHODS OF DIAGNOSIS

The discovery of increased water mobility around Tau protein tangles offered the researchers new clues towards practical medical applications: *"The fact that water mobility increases around tangles might provide an early stage diagnosis of Alzheimer's disease using methods such as diffusion magnetic resonance imaging. This discovery opens the way for scientists to study whether or not such diagnostic tools are sensitive enough to detect this difference in water mobility."* explains Yann Fichou, the PhD student in charge of the project.

A FIRST STEP TOWARDS A MORE GLOBAL UNDERSTANDING OF IDPS

The choice to study Tau proteins was no accident. *"Alzheimer's is one reason for studying Tau proteins. But the protein is also an intrinsically disordered protein (IDP), which is one of the main types of proteins in the human body. As a result, our findings could be applicable to a whole subset of proteins. The next step will be to confirm if this discovery can be generalized to all IDPs."* says Weik. The importance of making such a generalization is not to be underestimated given that IDPs are implicated in a number of diseases from Alzheimer's to Parkinson's.

"In fact, we have already launched a project to study the role of water dynamics in Alpha-synuclein, a protein that is one of the pathological hallmarks of Parkinson's." announces Härtlein.

> *"The discovery of surface water mobility on Tau protein could provide an early stage marker for Alzheimer's disease"*

GIANT EFFECT

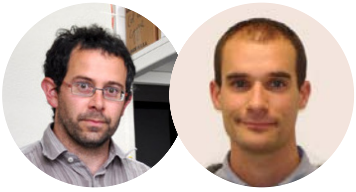
The Partnership for Structural Biology unites the ILL, the ESRF, the EMBL and the IBS within the GIANT campus. Having access to a neutron reactor and a synchrotron on the same site is exceptional. The fact is, we can cross the street and discuss our ideas with the ILL's neutron scattering and deuteration experts. This optimizes our chances for a successful experiment.

MARTIN WEIK
Research group leader at the IBS

On the Frontier of QUANTUM HYBRID SPIN MECHANICS

The Institut Néel is a fundamental research laboratory in the field of condensed matter physics. Olivier Arcizet and Benjamin Pigeau, researchers in the field of quantum physics, recently unveiled their team's latest discovery. The researchers discuss with us the results of their cutting-edge experimentations.

#Energy — #Fundamental Research



Q Your experiment looked at spin qubits. Can you explain a qubit and more specifically the spin qubit?

Qubits are the building blocks of quantum physics. Think of them as the quantum version of a classical bit. The primary difference is that a classical bit is either 0 or 1 - on or off - whereas qubits are quantum-mechanical systems that can be in a superposition of both states. Physicists have investigated many qubits such as polarized photons, superconducting qubits, single ions, and solid state electron or nuclear spin. In our case, we studied a single electron spin, which is an expression of the possible states of an electron using quantum numbers. Such an isolated spin can be found in a nano-diamond, where it gets trapped in a crystallographic defect called a Nitrogen-Vacancy.

Q How did you study a spin qubit? What did you observe?

Qubits were traditionally manipulated by electromagnetic fields. This made it possible to visualize and measure the complex dynamics at play. Our goal in this experiment was to couple the qubit to a nano-mechanical oscillator. This allowed us to manipulate the spin with both photons and phonons, the latter of which are the quanta of vibrational mechanical energy.

Using the setup sketched in the figure, we demonstrated that the single spin precession was synchronized with the mechanical vibrations. Observing such a new regime illustrates the strong coupling achieved between our spin and the phonons.

As a result, we were able to use phonons instead of photons to reproduce one of the fundamental signatures of quantum electrodynamics, called the Mollow Triplet.

Q Can you explain your findings?

The Mollow Triplet refers to the three frequencies observed within the fluorescent spectrum of an atomic vapor strongly illuminated by a resonant laser field. The triplet was predicted in 1969 and first observed in 1975, paving the way towards further experimental tests of quantum electrodynamics.

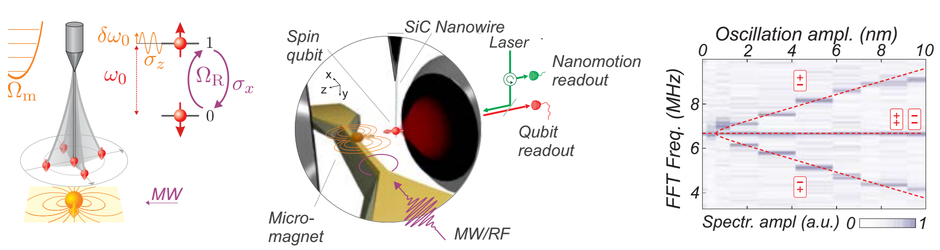
Until now, observations of this effect were carried out with photons driving the qubits. Our experiment demonstrates the first phononic expression of this interaction wherein a vibration field is responsible for the spin qubit manipulation.

Q What do these finding imply for future research?

By demonstrating these signature effects, we illustrate that it is possible to develop new approaches to mechanically manipulate a single qubit using a nano-oscillator. We have produced the foundations that will allow us exploit the reverse effect: to read the quantum state of a single spin with a mechanical oscillator. In such a coupling regime, the nanoresonator is expected to experience a very weak force (20 attonewton, 2ᵉ-17 N) that will depend on the spin state. This force is extremely weak but within the detection capacity of our nanoresonators.

In the future, such approaches could be used to create and manipulate non-classical states of motion with macroscopic oscillators.

The hybrid nanomechanical system couples a two level system: a spin qubit attached to the vibrating end of a mechanical nano-oscillator. By immersing the system in a strong magnetic field, the qubit state becomes coupled to the nanowire vibrations. The spectrum of the qubit, which was excited by a microwave field, allowed us to observe the phononic equivalent of a Mollow Triplet, thus revealing the intrinsically non-linear dynamics of quantum driven two-level systems.



NeOse™: Creating an Electronic Description of WHAT YOU SMELL?

Nearly 10% of the world population is believed to suffer from olfactory disorders. Whether it is the inability to detect odors or an altered sense of smell, olfactory disorders can lead to depression and desocialization. In response, Aryballe Technologies has been working with Grenoble Ecole de Management researchers to launch NeOse™, a portable odor detection device.

#Health — #Technology Management

Aryballe Technologies and Vincent Mangematin, head of research at Grenoble Ecole de Management, have been working together to launch this new technology. *"Anosmia, or the inability to detect odors, has yet to be formally recognized as a disability. One of our primary objectives is to organize the process through which governing authorities will recognize olfactory disorders. We have a technology, a startup and potential markets, but there is also a crucial societal contribution."* says Mangematin.

PAIRING TECHNOLOGY AND MANAGEMENT RESEARCH

The second challenge is to develop a business model for NeOse™. *"This technology has enormous market potential, from household appliances to medical applications or the fragrance industry. The advantage of working with management researchers during the development process is that we can help guide the process by exploring potential markets in advance."* adds Mangematin.

AN ELECTRONIC SIGNATURE COULD REVOLUTIONIZE THE WORLD OF ODORS

Currently, it is impossible to patent an odor. The difficulty lies in the fact there is no standardized method to describe a smell. Yet, as Mangematin explains: *"This innovative technology has the potential to create an electronic signature for any odor. Whether it is fragrances or flavors, which are also based on odors, the ability to precisely define what we smell will revolutionize any industry that relies on odors."*

RESEARCH TO DEVELOP A DATABASE OF ODORS

Before marketing a technology to detect odors, it is essential to define how the technology will catalogue each smell. Current research is focused on defining standards for signatures and a validation process. *"The goal is to create a single internationally-recognized database. We are launching a chair that will be dedicated to this topic because it offers great potential for business and society."* concludes Mangematin.

GIANT EFFECT

"This collaborative effort highlights the importance of the GIANT ecosystem. These partnerships are developed thanks to networking and activities that go beyond the business world. Whether it's by skiing together or any other activity, such relationships allow us to truly build cooperation between business, academia and research."

VINCENT MANGEMATIN
Head of research at Grenoble Ecole de Management

NEOSE™: THE ABILITY TO RECORD A SMELL

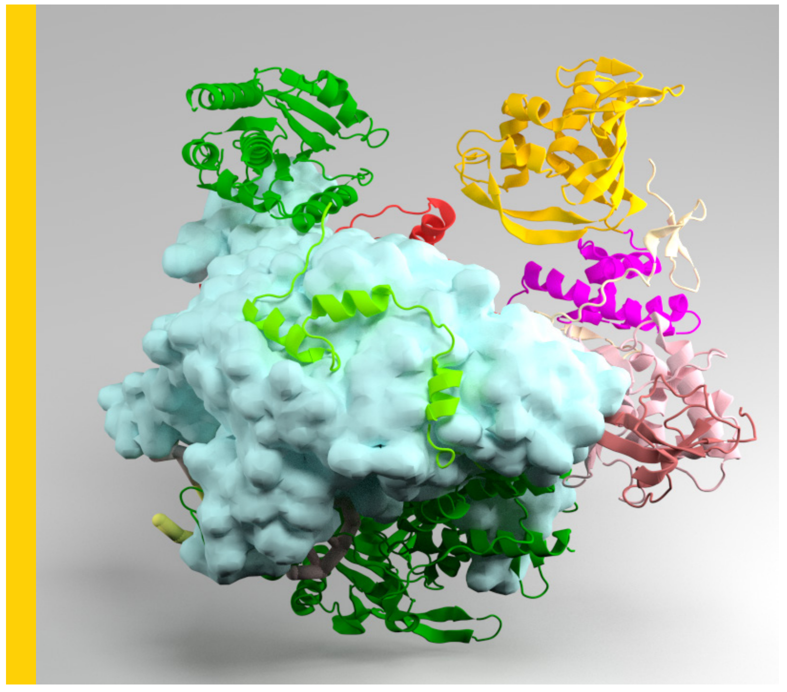
This odor detection device is based on technology developed by the CEA and the CNRS. Aryballe Technologies has used this technology to create what could be the world's first portable device to detect and catalogue smells. The device works by absorbing molecules (odors) which then interact with chemical sensors. These sensors help produce an optical signal which can be recorded and sent to the database.

After 40 Years of Research, **KEY INFLUENZA STRUCTURE FINALLY UNVEILED**

The influenza virus, more commonly known as the flu, remains a global threat with anywhere from 250,000 to 500,000 deaths per year. For the first time ever, researchers at the European Molecular Biology Laboratory (EMBL) have presented the complete structure of the influenza RNA-polymerase, which will be a game changer in the fight against the flu.

#Health — #Large Scale Facilities

The flu is an RNA virus which enters the human body through the respiratory track. A key part of understanding a virus is understanding its transcription and replication process – or how the virus reproduces within the host cell. To copy itself, the flu virus uses an enzyme called an RNA-polymerase. The polymerase replicates the viral genome and synthesizes gene transcripts. These transcripts highjack the host cell's machinery to create protein molecules, which in combination with genome copies are the building blocks for new virus particles.



Digital rendering of the flu polymerase structure

POLYMERASE STRUCTURE ESSENTIAL FOR DRUG ADVANCEMENT

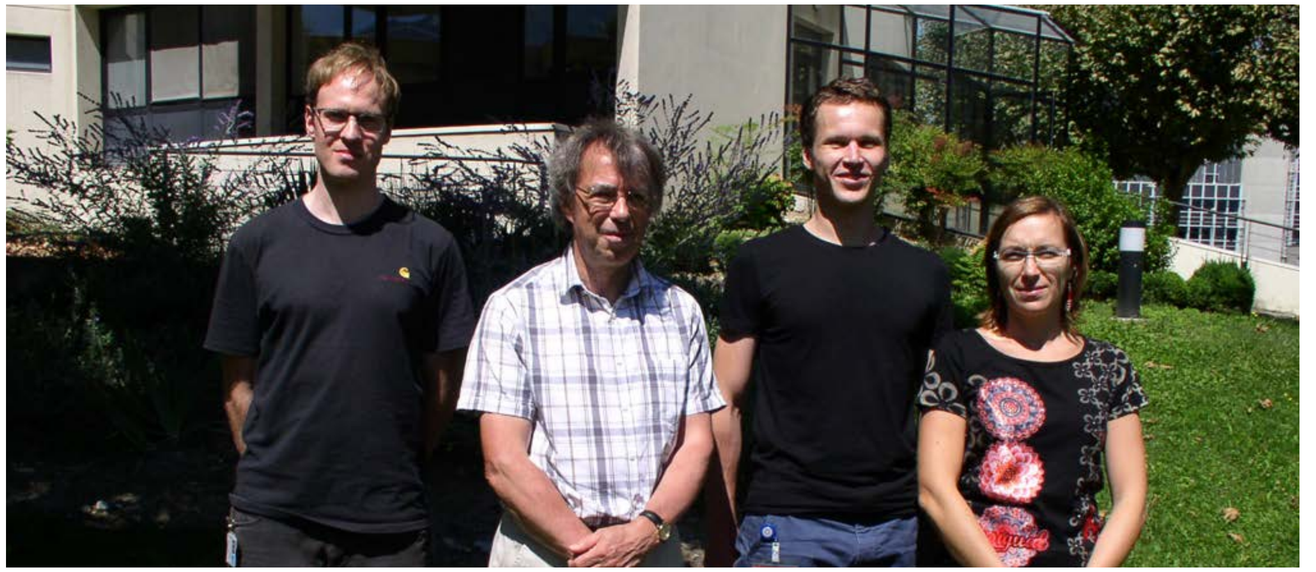
One particularity of the virus is its ability to mutate rapidly. This increases the risk of pandemics and decreases the effectiveness of most anti-flu drugs. Many of the most effective drugs used to treat viruses such as HIV or Hepatitis C have targeted the virus's replication machinery. Up until now, it was impossible to target the flu with the same efficiency because the structure of the RNA-polymerase was unknown. However, a team of researchers led by Stephen Cusack, director of the EMBL Outstation in Grenoble, used X-ray crystallography to produce a high-quality rendering of the polymerase.

> ***"A complete 3D model of the flu virus polymerase will help advance drug discovery."***

"By using high-intensity X-ray beamlines at the European Synchrotron Radiation Facility (ESRF), equipped with cutting-edge Dectris detectors, we were able to obtain high-quality data that allowed us to create a 3D atomic model of the flu's RNA-polymerase." explains Alexander Pflug, an EMBL postdoctoral researcher and member of the team that unveiled the first ever complete model of a flu virus polymerase.

RESEARCHERS STUDY TWO STRAINS OF INFLUENZA

The researchers were able to determine the atomic structure of the polymerase for two strains of the flu. They looked at a strain of influenza B, which only circulates in humans, and a strain of influenza A, which is found in bats. Understanding how influenza A strains replicate is particularly important as they circulate among humans and animals. As a result, influenza A strains evolve rapidly and are the primary threat for global flu pandemics.



EMBL research team (from left to right): Stefan Reich, Stephen Cusack (group leader and director of the EMBL Outstation in Grenoble), Alexander Pflug, Delphine Guilligay

"Our atomic models of the polymerase provide us with insights to understand how the virus uses the host cell to launch the production of its proteins. In short, we have exposed how the polymerase forces the host's RNA transcripts to carry viral genes, thereby reprogramming the host cell to produce new infectious virus particles." explains Pflug.

A FUNDAMENTAL PART OF THE VIRAL INFLUENZA MACHINE

"To understand the importance of the polymerase, you just have to consider that the polymerase represents more than 50% of the virus's genetic information. In addition, we learned that the flu polymerase is similar to polymerases in a whole host of viruses such as Ebola, Measles or Lassa fever." says Pflug. The researchers are building on their discovery to try and determine the structure of an influenza A strain that affects humans. This is the next step needed to effectively create drugs that target the virus's replication machinery. In order to have a more complete perspective of polymerase functions, the researchers at the EMBL are also working to capture images of the polymerase's structure in different states of activity.

CRYSTALLOGRAPHY: COMBINING TECHNOLOGY AND PATIENCE

A single polymerase is too small to be observed with a microscope. Yet in terms of proteins, the flu polymerase is relatively large. This makes it a particularly difficult sample for crystallographic studies. To overcome this challenge, researchers at the EMBL created a protein crystal, or a 3D lattice in which the virus protein repeats regularly. Successfully growing a protein crystal is a major challenge that can last anywhere from one to 20 years!

The researchers then fired high-intensity X-rays at the protein crystals and recorded the diffraction patterns. By analyzing how the X-rays were diffracted, they were able to recreate the structure of a single polymerase.

One of the research team's remarkable achievements was to grow high quality crystals that are good enough to also be used for the purposes of drug discovery.

GIANT EFFECT

We were only able to obtain such high-resolution renderings of the polymerase thanks to the high-intensity X-ray beamlines at the European Synchrotron Radiation Facility (ESRF). Crystallography can be a very long process and require many trips to the synchrotron. Being located next door made it possible for us to go every week when necessary.

ALEXANDER PFLUG
EMBL postdoctoral researcher and member of the team that unveiled the first ever complete model of a flu virus polymerase

FOCUS

GIANT: Exploring the Hidden Facets of the Digital Revolution

Connected objects, cloud computing, social networks, e-health, energy efficiency… The impact of digital technology is everywhere. As scientists at GIANT study everything from the smallest building blocks of matter to the most complex and interconnected systems, they capitalize on the opportunities created by the digital revolution. Through big data, cybersecurity, business and fundamental research, we delve into some of the lesser known challenges of digital technology.

Big data

Exploring the unexpected

"We are facing a tidal wave of information." highlights Christine Collet, a professor at Grenoble INP and director of the MaDICS lab. In terms of data, the world has entered the zettabyte era. For the less mathematically inclined: If your standard cup of coffee equals one gigabyte, then a zettabyte packs the same volume as the Great Wall of China (source: Cisco Visual Networking Index).

What is responsible for this massive increase in data? *"The dramatic drop in the price of data storage units and the digitalization of all human activities has created an explosion of data streams. This has been amplified by the widespread adoption of connected devices (iPhones, tablets, connected objects, etc.)."*

Big data creates several challenges for scientists: *"Massive amounts of data are arriving in continuous streams from an ever-growing number of sources. Simply designing new tools and systems is not enough to handle the growing scale, velocity and variability of data. We need innovative algorithms that can adapt to and be in part guided by data itself. Data is in fact the new code."*

Using data science to monitor health and nutrition

The MASTODONS CrowdHealth project used data science to analyze millions of tweets in English and look for correlations over time between demographics and nutrition, health or lifestyle. Marianne Clausel, an associate professor at the Laboratoire Jean Kuntzmann worked on the project with her colleagues, Massih Reza-Amini and Sihem Amer-Yahia. She explains: *"My part of the project focused on tracking individual health. We worked on creating a model that represents the evolution over time of an individual's tweets about ailments such as the flu or stomach aches. The model highlights time periods when various ailments are more common. Social media offer a wealth of information that can lead to both expected and unexpected observations."*

Cybersecurity

Expertise in physical cybersecurity

"Digital technology has entered the physical world. Whether its credit cards, passports, smartphones, connected objects, industrial systems or automotive technology, connectivity has made cybersecurity a priority for many industries that are not used to thinking in terms of security first." explains Alain Merle, head of marketing for cybersecurity at the CEA-Leti. With billions of connected objects interacting in the physical world, protecting their physical entry points is only possible thanks to expertise in areas such as microelectronics and the physical implementation of security. The CESTI at the CEA-Leti is a licensed laboratory for security evaluations and a world leader for testing the physical security of digital systems.

Computer code that mutates

In addition to physical security, GIANT researchers also work on software security. The COGITO project aims to improve cybersecurity by using code that can change each time it runs (known as polymorphic code). To understand this innovation, you have to see cybersecurity as a combination of multiple layers that try to protect secret information such as an encryption key. *"By comparing the behavior of a program overtime, hackers can deduce an encryption key or understand how to bypass security measures. This comparison process is based on the fact that programs repeatedly run in the same way. However, by using polymorphic code we can modify the form and behavior of a program without changing its user functionalities. For a hacker, this makes it difficult to compare one runtime to another."* explains Damien Couroussé, COGITO project coordinator and researcher at the CEA.

Business

Extracting value from digital data streams

For Federico Pigni, data management is a challenge of the past: *"Companies have been managing data for a long time. However, the digital revolution has created lots of new data streams which companies don't know how to capitalize on. In fact, companies often separate their IT departments from other business units and see data management as a necessary evil without considering its value. It's one of the reasons we are looking to bridge the gap between data and value management."*
When every tweet, Google search, email, smartphone application or connected object creates digital data, there is real potential for value creation. The Grenoble Ecole de Management researcher explains: *"Before you had a thermostat and a fire detector. Each one had its own purpose. Now, the Internet of Things (IoT) allows the two objects to interact. The fire detector detects smoke; it tells the thermostat to turn off the heating. Add internet connectivity to the mix and the objects can also send a message to your smartphone or alert the fire department."*
What does the future hold? *"We are entering an era of self-organizing digital systems. IoT has created a direct link between the physical and digital worlds. As objects interact with each other and humans, they can discover and do things without our input. The key is for companies to have the right mindset, skills and resources to discover and capitalize on this potential."*

Fundamental research

Combining big data and open data

Open data accessible to all has become a hot topic of discussion as many major research facilities produce enormous amounts of data. The Large Haldron Collider produces almost 15 petabytes (PB) of data every year – or the equivalent of three million DVDs. The Large Synoptic Survey Telescope under construction in Chili is expected to produce more than 30 terabytes of data every night. The Upgrade Program launched by the European Synchrotron Radiation Facility (ESRF) will cause the facility to produce 15PB per year.
In response to this, the ESRF has adopted a data policy and hired its first data manager. *"We used to only store backup data for scientists during their experiments. But the size of datasets makes it no longer reasonable for scientists to manage all data collected by their experiments. In addition, by storing ESRF data in one place, we provide traceability. As science relies more and more on data, it is essential we guarantee its authenticity. We will be able to record when, where and how data was obtained."* explains Andy Gotz, head of the ESRF software group. ESRF data sets will become publicly available after a three year embargo period to give scientists the time to exploit data they helped create.

GIANT EFFECT

The explosion of connected objects has made technology an essential part of our physical and social environments. Take for example the potential of a connected refrigerator: It can not only store food, but also inform us when food has spoiled, and track our nutrition habits or energy consumption – an intersection of household appliances, energy efficiency and health care thanks to digital technology.

The complexity of the digital revolution requires interdisciplinary research that considers everything from individuals to society as a whole. The Grenoble region unites actors that cover the entire chain of digital technology from the smallest nanotech to end-user interactions. Through collaborative efforts such as the GIANT campus, our academic institutions, companies and local authorities can achieve a change in paradigm: to evolve from sector-specific visions (e.g. smart energy, smart health or smart dust) to a holistic and interactive strategy to empower people while caring for the environment (e.g. energy harvesting).

GAELLE CALVARY
In charge of the Grenoble INP mission for a Digital Society and a professor at Grenoble INP - Ensimag

Illustrations: ©Studio Bambam

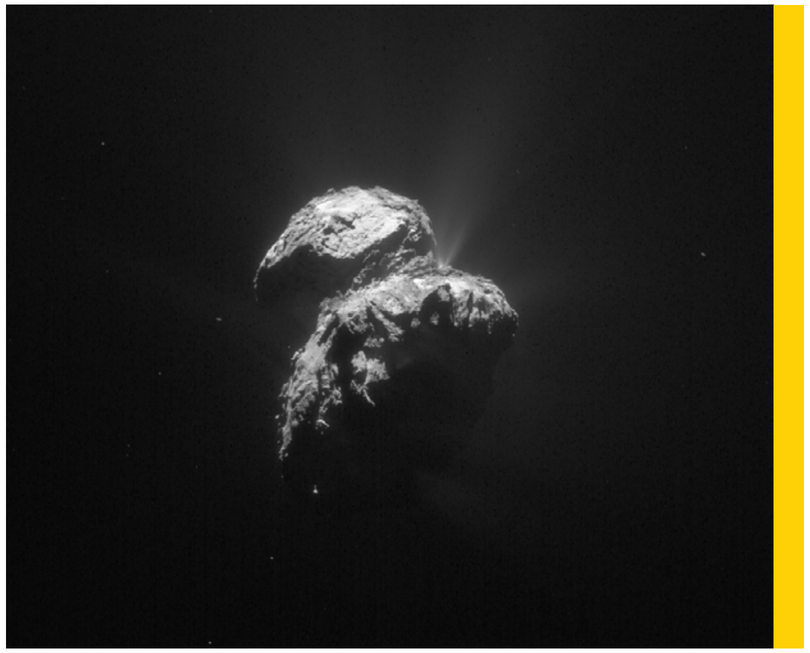
ROSETTA SPACE MISSION:
Unlocking the Secrets of the Solar System

Researchers from the CNRS and the Université Grenoble Alpes (UGA) participated in a ten year journey to observe and analyze Comet 67P/ Churyumov-Gerasimenko. The data gathered from numerous instruments onboard the Rosetta spacecraft has provided scientists with a wealth of new information to understand the formation of our Solar System.

#Fundamental Research

Visiting a comet that comes from the outer edges of our Solar System is a dream that dates back to the 1980s. By analyzing the composition of comets, scientists can discover information about the state of the Solar System at the time of its creation. The Rosetta spacecraft rendezvoused with Comet 67P in August 2014 after a ten year journey that included orbits around the Sun, flybys of Earth, Mars and two asteroids as well as a two and half year hibernation period.

Equipped with 20 instruments, the mission brought together an international team of scientists. Researchers at GIANT contributed to two instruments: the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) and the Comet Nucleus Sounding Experiment by Radiowave Transmission (CONSERT).



Comet on 22 November 2015 NavCam

Interview with BERNARD SCHMITT
CNRS Director of Research at the IPAG (CNRS-UGA)/OSUG (Grenoble Institution for Planetary Sciences and Astrophysics) and co-investigator for the VIRTIS instrument.

Q *What data was collected by VIRTIS?*

Like most teams working with the spacecraft's various instruments, we are still analyzing the data sent back by VIRTIS. However, the instrument made several surprising discoveries. VIRTIS's measurement of albedo, or the amount of sunlight reflected on the comet's surface, was only 6% – making the comet one of the darkest objects in our Solar System. Further infrared observations also allowed us to detect a high concentration of organic compounds. Finally, VIRTIS identified and helped us understand the comet's water-ice cycle.

Q *What is the significance of detecting organic compounds in the comet's composition?*

Understanding the beginning of the Solar System is a matter of piecing together many parts of a very big puzzle. One piece of this puzzle is that we discovered macromolecular compounds similar to the carboxylic acids present in amino acids. In other words, we found molecules composed of carbon as well as nitrogen and oxygen, which are the first steps of prebiotic chemistry. These molecules are present in a frozen state which requires extremely low temperatures. With this information, we can posit that the comet was formed far away from the Sun where it was cold enough for such molecules to freeze. This could indicate that the comet dates back to the beginning of the Solar System, and therefore provides us with unaltered examples of the materials present during the birth of the system.

"The 20 instruments on board the Rosetta spacecraft have added many pieces to the vast puzzle that is our Solar System."

Q *What is the comet's water-ice cycle?*

Comets have already been observed to spew jets of vaporized water from their surface. Thanks to VIRTIS, we were able to understand this cycle. Various areas of a comet are exposed to the Sun during the comet's rotation cycle. Exposure to sunlight heats the surface and its underlying layers causing ice to vaporize. Once the area rotates back into the shadows, the surface of the comet cools down quickly. However, deeper layers remain warm for longer periods. As a result, vaporized water continues to move towards the surface where it crystallizes due to the rapid change in temperature. This process creates a thin layer of frost on the comet's surface. As the area comes into the sunlight again, the frost vaporizes almost instantaneously. This creates the characteristic jets of vaporized water which had been previously observed on other comets such as Halley's Comet.

Q *Did Rosetta also send back information about the formation of comets?*

With 20 instruments onboard the Rosetta spacecraft, we have just added many pieces to the puzzle. For example, current theories about comet formation generally see comets as *"fluffy snowballs"* made up of small grains. However, VIRTIS discovered that the comet is made up of ice grains of varying sizes. One region of the comet had very small grains that were only a few micrometers large, which is what we expected. On the other hand, another region displayed larger grains that went from a few micrometers to two millimeters in diameter.

Q *How do these unexpected observations influence our understanding of the Solar System?*

With this new data, we have to try and understand if these larger grains are the result of transformations during the comet's life cycle, or if they date back to the comet's formation. If these larger grains were present at the beginning, this could undermine our entire understanding of comet formation.

Right now, we are still analyzing data instrument by instrument. However, once we start trying to combine all of this information to see the big picture, we might even develop a completely new theory about the formation of the Solar System

Close view of the comet surface showing various unexpected geological features, such as layering and cracks. OSIRIS narrow-angle camera image taken on 23 January 2016, when Rosetta was 75 km from Comet 67P/Churyumov-Gerasimenko. The scale is 1.3 m/pixel.

SYNCHROTRON
Offers Peek into Charred
HERCULANEUM PAPYRI

For more than two centuries, the most carbonized papyri discovered in Herculaneum have eluded researchers' attempts to unlock their secrets. However, an international team of scientists has successfully used a beamline at the European Synchrotron Radiation Facility (ESRF) to detect Greek letters on the surface of the papyri.

#Large Scale Facilities — #Fundamental Research

In 1752, more than 18,000 scrolls and fragments were discovered in a villa that was covered by the eruption of Mont Vesuvius in 79 AD. Located in the Roman town of Herculaneum, the villa holds the only complete library to survive from antiquity. The library's scrolls were dated between the third century BC and the first century AD, when Herculaneum was a flourishing Roman town. The majority of the scrolls are written in ancient Greek and include fragments of works such as Epicurus's treatise *On Nature* or the writings of Philodemus of Gadara.

SCROLLS CHARRED BEYOND RECOGNITION

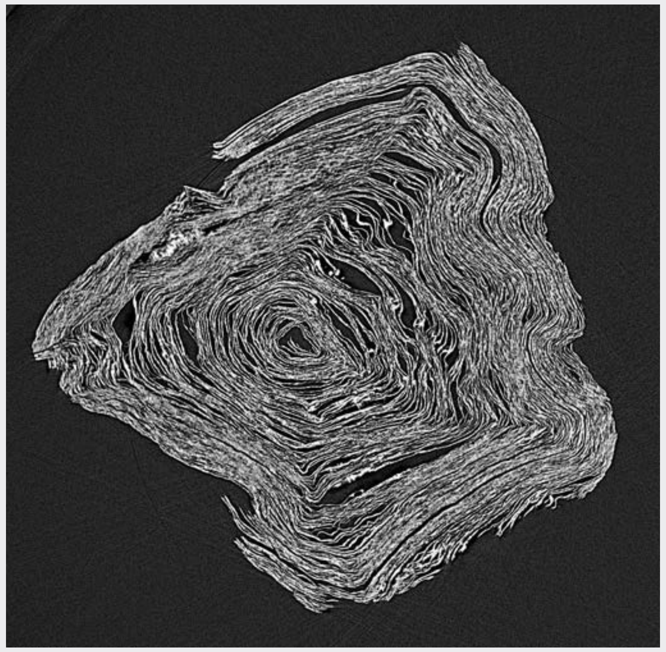
The challenge of reading the literary works enclosed within these scrolls lies in the fact the eruption burned the papyri at around 300 degrees Celsius. A furnace-like blast of gas from the volcano not only charred the scrolls, but also deformed them. For two centuries, scientists have attempted to open the scrolls by various means, all of which have led to their destruction. The most successful method was a mechanical approach dreamed up by Antonio Piaggio in 1754. The method continued to be used up until the 20th century to unroll the most well-preserved scrolls. However, with only 400 to 500 of the most burnt scrolls remaining, the priority has been to find a method that could read the scrolls without opening them.

A non-destructive technique to read the papyri of Herculaneum

ESRF BEAMLINE DETECTS LETTERS WITHIN THE SCROLLS

One of the difficulties of looking inside the scrolls is the fact that the composition of burnt papyrus is quite similar to the composition of burnt ink making it impossible to count on conventional X-ray techniques used in archeology and paleontology. The researchers were able to overcome this challenge by using a technique known as X-ray Phase Contrast Tomography (XPCT), which had been primarily used for biomedical research. *"Unlike the absorption indices used by conventional X-ray techniques, the use of XPCT at the ESRF beamline allowed us to go a step further and measure how the materials refracted X-rays. This refraction index is 100 to 1,000 times higher than X-ray absorption indices. As a result, we were able to detect ink letters that were only two to three tenths of a millimeter thicker than the papyrus."* explains Emmanuel Brun, co-author of the article published in Nature Communications and an INSERM researcher located at the ESRF and formerly at the Ludwig Maximilians University (LMU).

ESRF-Synchrotron



A section of papyrus. Letter sequences were found in a fragment of a hidden layer.

GIANT EFFECT

The X-ray properties of the European Synchrotron Radiation Facility (ESRF) made it possible to see inside a Herculaneum scroll without damaging it. This work proves, once again, the extremely high efficiency of phase contrast imaging. The GIANT campus provided us with access to the only beamline option in Europe that made this research possible.

EMMANUEL BRUN
Researcher at the INSERM and previously at the ESRF and LMU

A QUICK AND NON-DESTRUCTIVE TECHNIQUE

The scan of a scroll and a fragment took researchers only five hours each. By comparison, Antonio Piaggio's mechanical technique took a year to open three meters of one scroll. Using the XPCT technique, researchers reconstructed almost an entire alphabet from the rolled-up papyrus. Once scientists have fine-tuned the imaging process, an entire scroll could be made visible with only a few hours of synchrotron beam time.

ANCIENT TEXTS INTERSECT WITH BIG DATA

The XPCT scans of these two papyri demonstrated the feasibility of the technique. However, the most crucial problem must now be solved: *"Imaging an entire scroll produces a wealth of data that has to be analyzed. The key challenge will be to create algorithms that can reconstruct a virtual image of the scroll."* highlights Brun. While the XPCT technique will be able to read the letters in future scrolls, the fact the scrolls are deformed leaves researchers to sort through lots of jumbled data. This intersection of big data and papyrology means the scientists are only at the beginning of the adventure. They still have several years of work ahead to scan scrolls and develop algorithms to unlock the secrets of the remaining papyri of Herculaneum.

"The combination of papyrology, ESRF equipment and big data is a chance to unlock the secrets of the Heraculaneum paprYi."

GIANT Researcher Awarded 2015
ERC Proof of Concept Grant

Conducting a successful research project is a challenging experience for numerous reasons, not the least of which is to obtain funding. On October 16th 2015, the European Research Council (ERC) awarded a Proof of Concept grant to Catherine Picart, a professor at Grenoble INP. The grant provides her team with key support to test the innovation and commercialization potential of their work.

#Health

As with all ERC grants, the Proof of Concept grant is awarded on the basis of scientific excellence. It is open to ERC grantees who wish to build on discoveries made during research for a Starting, Consolidator or Advanced ERC grant. The goal is to support innovation by helping fundamental research transition to market.

A FIRST ERC GRANT IN 2010

With her first ERC Starting grant in 2010, Picart, who is also a researcher at the Materials and Physical Engineering Laboratory, received funding to pursue her research of biomimetic materials developed via tissue engineering and designed to elicit cellular responses. *"We aimed to develop multifunctional materials based on biopolymers. The goal was to control the materials' characteristics to better understand cellular behaviors and how cells develop to form bone or muscle tissues."*

TWO PROOF OF CONCEPT GRANTS

With her Starting Grant, Picart and her team developed new biomaterials that showed potential for musculoskeletal tissue engineering and guided bone tissue regeneration. In 2012, her first Proof of Concept grant provided her research team with funding to test the pre-clinical efficiency of these newly created biomaterials. Her 2015 Proof of Concept grant was awarded to test the efficiency of related bioactive coatings.

NAVIGATING THE ERC GRANT APPLICATION PROCESS

With three grants under her belt, Picart is becoming an expert on the application process. Reminiscing on her first ERC grant application, she highlights: *"The interview process is particularly tough. It's very short. You have 12 minutes to demonstrate not only your abilities as a researcher, but also as a manager who can lead a major research project."*
"The key is preparation. I spoke with previous ERC laureates. The CNRS also provided me with the opportunity to do a mock interview in Paris." Before hoping for a grant interview, candidates must write and submit their proposals. *"Compared to other calls for projects, the proposal isn't very long. The challenge is to be concise yet convincing."*

SUPPORT TO IMPLEMENT ERC GRANT RESEARCH

Major research projects such as those supported by ERC grants also require administrative support. *"My laboratory provided me with precious support to manage everything from recruitment to ordering supplies. In addition, every 1.5 years, ERC grantees have to justify their spending. Support from the CNRS and Grenoble INP was crucial to help us produce financial reports."*

GIANT EFFECT

"In addition to the support services provided by each institution, the GIANT alliance has launched the FOSTERING initiative to help researchers obtain competitive funding and carry out high-level research at one of our partner institutions. Keeping track of funding opportunities, application deadlines and necessary paperwork is too big a task for any single individual. From ERC grants to other funding opportunities such as the Marie Sklodowska-Curie Actions, we provide researchers with information and support services such as personalized coaching, mock interviews or experts to help edit proposals."

THIBAUT DAVID, PHD
In charge of the FOSTERING program and coordinator of scientific programs within GIANT

- GIANT - CAMPUS *LIFE*

Events All Year Long

May-July & Sept.-Dec.

GIANT INTERNATIONAL INTERNSHIP PROGRAM (GIIP)

Since its launch in 2011, the GIIP has welcomed 115 non-European interns to participate in the work of various laboratories on the GIANT campus. The internships run twice a year from May to July and September to December. Undergraduate and graduate students from partner universities have the opportunity to carry out a ten to twelve week full-time internship. In addition, interns take part in a series of visits to discover other GIANT laboratories and facilities. The campus also organizes cultural and social events to help interns integrate the local community.

June

GIANT ADMIN DAY

An event dedicated to sharing experiences and providing administrative assistants with training on the latest tools.

June

FRENCH AMERICAN WORKSHOP (FAW)

Promoting French-American cooperation on research.

July

INNO CUP JUNIOR

A biannual competition to encourage youth innovation.

All-year round

FOSTERING DAYS

GIANT support services for European grant candidates.

September

SUSTAINABLE MOBILITY DAY

A freely accessible fair dedicated to sustainable mobility.

October

GRENOBLE EKIDEN

A six person marathon relay race (42.195 km) with free workshops and events for children.

October

SCIENCE FESTIVAL

A festival dedicated to popularizing research and science.

October

EDF ROWING TROPHY

A yearly rowing competition for companies and associations.

March

JUNIOR SCIENTIST AND INDUSTRY ANNUAL MEETING (JSIAM)

Conferences, round table sessions and industry networking to help junior scientists and industry members interact.

All-year round

STARTUP CAFÉ

GIANT support services for European grant candidates.

GIANT@SCHOOL

The GIANT@school initiative covers the various campus events geared towards high school students. In collaboration with the school district of Grenoble, GIANT offers students the opportunity to participate in conferences, lab visits and experiments as well as discover the campus, which has various tools to help them learn about scientific careers. GIANT@school includes four year-round programs (Nano@school, Synchrotron@school, Innov@school and the Physiquarium) and yearly events such as ScientifiqueToiAussi!, Olympiades and the Inno'Cup Junior.

giant-grenoble.org

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