» INTERVIEW

AN INFRASTRUCTURE FOR INTERDISCIPLINARY RESEARCH IN THE HEART OF EUROPE

Interview with Francesco Sette, Director General of the European Synchrotron Radiation Facility (ESRF)

Light for Science. This expression encapsulates the mission of the European Synchrotron Radiation Facility (ESRF)and is the perfect slogan for the UNESCO International Year of Light. It is light itself, specifically synchrotron radiation light, the main focus of this centre of excellence for basic, applied and industrial research, which uses and makes available to the international scientific community the most intense source of X-rays of the world, a hundred thousand billion times brighter than the X-rays used inside hospitals. Synchrotron light is electromagnetic radiation, emitted by *relativistic electrons* through a wise manipulation of their trajectory with powerful magnetic fields. Infact, photons with various wavelengths ranging, from infrared to hard X-rays, are created when electrons are driven at a speed close to the speed of light inside a storage ring, and are deflected by magnetic fields.
Opened in 1994 in Grenoble, France, ESRF was founded also thanks to the expertise at INFN, especially at the *Frascati National Laboratory*, involved from the beginning in the design of the storage ring of ESRF. Supported by 21 partner countries from three different continents and attended every year by 6,000 scientists, 13% of whom are Italians, ESRF is a great example of international cooperation. Among the supporting countries, Italy is one of the main contributors, after France and Germany, with 13.2% of the budget, one third of which is under responsibility of INFN.
The Grenoble machine, an 844-metre circumference ring, is the same size as a football stadium and produces numerous X-ray beams: there are 43 experimental stations, called *beamlines*, each of them highly specialized in different areas of research. Because of its versatility, the ESRF receives about 2,000 proposals for experiments every year, between 1994 and 2014, there are been more than 25,000 scientific publications.

We met Francesco Sette, Director General of ESRF. He is a matter physicist who studied at the *Frascati National Laboratory*, and one of the pioneers in synchrotron radiation research.

» INTERVIEW

What is the ESRF research infrastructure's mission?
ESRF operates as a *super-microscope*, able to reveal the structure of matter in all its beauty and complexity. Observing and decoding the properties of materials and of living matter is fundamental to obtaining a better understanding of the origin of nature, and to improving the world around us, or to conceive more efficient and effective materials. For these purposes, ESRF hosts thousands of scientists from all over the world, and develops partnerships in strategic industries.

What are the main applications of synchrotron light?
At ESRF thousands of scientists from different disciplines work closely together: material physicists, material chemistry scientists, structural biologists, archaeologists, cultural heritage experts, nanotechnologists, IT engineers, geologists and doctors. They go to Grenoble to perform a variety of experiments, such as studying new materials, new drugs or complex chemical processes, but also to analyse archaeological artefacts, fossils and paintings. Indeed, in recent years, areas related in any way to cultural heritage have made increasing use of synchrotron light, which permits non-invasive and non-destructive studies. This technology, however, was created to explore the structure of matter at atomic and molecular level, through crystallography and X-ray spectroscopy of biological macromolecules; it can provide, for example, guidelines for developing new drugs. Other fields of research are real-time imaging of living cells and the study of new materials for next-generation electronics, such as graphene or volatile memories.

Can you tell us about the plan to design a new generation of synchrotrons between 2015 and 2022?
ESRF has embarked on a major challenge: opening a new window onto the nanoworld, at less than about 500 nanometers (billionths of a metre). The Upgrade Programme is an ambitious and innovative project of modernization involving an investment of €330 million between 2009 and 2022. With this programme - which includes, by 2015, the conclusion of construction of 19 next-generation experimental stations and, by 2020, a new storage ring within the existing one - ESRF is preparing to build the first of a new generation of synchrotrons, which will produce more intense, coherent and stable X-ray beams by a factor of 100. The aim is to improve, with unmatched nanometric spatial resolution, the analysis of materials and living matter, reusing 90% of the existing structure. The construction of the new ring will continue alongside the normal operation of the current machine until the end of 2018. Then, between 2019 and 2020, there will be a shutdown phase when operations will be halted for 18 months, to disassemble the ring, to assemble the new one and to do the *commissioning*. The date expected for a return of users is on june 1st 2020.

What is the role of INFN at ESRF?
ESRF was founded in the 1980s partly thanks to an idea from INFN which played a key role in the project's

» INTERVIEW

beginnings, for example in the design of the ring, and also thanks to the important work of Italian material physicists and high energy physicists, for example, with the unit of the *Frascati National Laboratory* operating with synchrotron radiation. These laboratories were important for me personally in my education as a physicist. In Frascati, I was part of the PULS group (a project dealing with applications of synchrotron light), which used the ADONE ring. Cooperation with INFN, however, is still ongoing, either as part of a wider interaction between institutions and European research infrastructures or about particular common projects of accelerators.

In which areas is this collaboration taking place?
In ESRF one of the major challenges for the future is the creation of more stable and reproducible *nanobeams*, in order to study matter with spatial resolution at nanometric scale. To achieve these scientific goals, however, in addition to the realization of a new generation of *beamlines* we need a brighter source, with a gain of brilliance by almost a factor of 100. This means that we need to develop a new machine with more revolutionary characteristics than today standards. The ESFR Accelerators Division has recently conceived and proposed a new storage ring, by working on an idea firstly originated by the leader of the Division, Pantaleo Raimondi, an Italian physicist coming from the *Frascati National Laboratory* and leading the group since 2012. Since a couple of years a strong ongoing collaboration is in progress with the *Frascati National Laboratory*, which researchers have an extensive experience in the field of leptonic storage rings, developed with the DAFNE (*Double Annular Φ Factory for Nice Experiments*) machine. The Frascati group, infact, is contributing to the development of sophisticated components like those for the vacuum system.
We are also developing a strong collaboration with INFN on *Big Data*, for the analysis, storage and access to scientific data produced by research infrastructures like CERN or ESRF. An exchange for the creation of *databanks* and *cloud resources* to connect various infrastructures is ongoing, for example, at an european level. Infact, ESRF produces every day around 10 terabytes (10 thousand billion bytes) of data, and these numbers will rise steeply next years, reaching numbers not much less than what is produced at the LHC. ■