ESRF
The European Synchrotron

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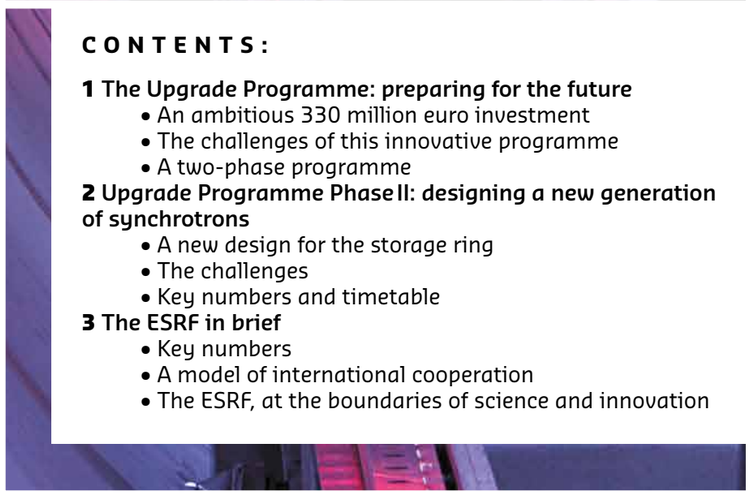
OFFICIAL LAUNCH OF THE UPGRADE PROGRAMME PHASE II

The **ESRF** designs a new generation of synchrotrons



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OFFICIAL LAUNCH OF THE UPGRADE PROGRAMME PHASE II

The ESRF designs a new generation of synchrotrons

Over the years the ESRF has become a world reference. By means of the Upgrade programme and thanks to the enthusiastic and collective support of the ESRF's Members and Associate countries, the ESRF is preparing for the future by constructing the first of a new generation of synchrotrons. The ESRF will lead the way in pushing back the boundaries of scientific exploration of matter. Sustaining its world-class users' programme, will contribute to answering to the great technological, economical, societal and environmental challenges confronting our world. The construction of this new lightsource, deeply rooted in the existing infrastructure, will allow Europe to strengthen its strategic position in this area of science with an exceptional return on investment and minimal disruption of the ongoing programme: this is possible and conceivable only thanks to the twenty years of experience and unique concentration of skills and expertise of the ESRF staff. I am confident that with the support of its scientific community and the motivation of its staff, this is a new era for the ESRF, for the history of synchrotrons and for the science that is now being written!

Francesco SETTE
Director General of the ESRF

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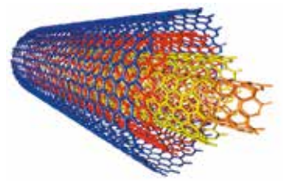
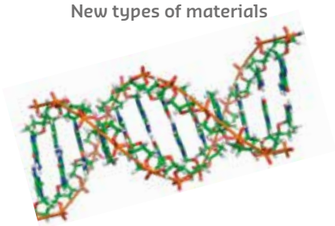
THE UPGRADE PROGRAMME: PREPARING FOR THE FUTURE



New types of materials



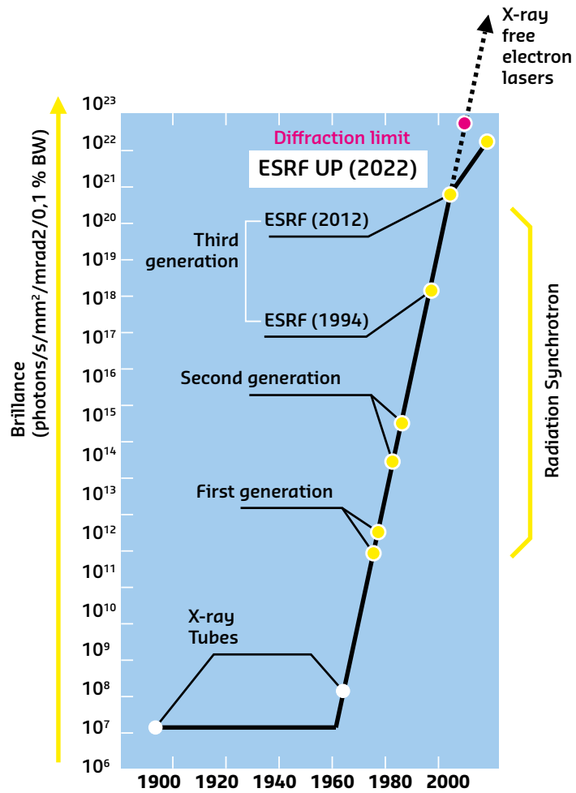
Health and life sciences

Energy and the environment

The ESRF – the European Synchrotron Radiation Facility – is the source of the most intense X-rays in the world. Its extremely brilliant light provides unrivalled opportunities for scientists all over the world in the exploration of materials and living matter in a very wide variety of fields, ranging from the chemistry and physics of materials to archaeology and cultural heritage, together with structural biology and medical applications, the sciences of the environment and the sciences of information and nanotechnologies.

Since its creation, the ESRF, the first one in the world among today's so-called third generation lightsources, has been breaking records including brilliance and stability of the X-ray beams, coherent light, and number of scientific publications. This has been made possible through continuous progress in the instrumentation and technology of the X-ray source and has enabled the ESRF to attain the position of world leader in the field. In 2009, the ESRF embarked on an ambitious 330 million euro modernisation programme – the Upgrade Programme, which encompasses two Phases, I and II.

Today, with the launch of the Upgrade Programme Phase II, the ESRF is tackling a new challenge: creating a new generation of synchrotrons and pushing back the boundaries of the scientific exploration of matter.



An ambitious 330 million euro upgrade programme

Following on from 20 years of success and scientific excellence, the ESRF has initiated an ambitious modernisation programme – the Upgrade Programme.

ESRF Upgrade Programme

- Brilliance and coherent flux of the X-ray source increased by a factor of around 100
- New storage ring
- New generation of X-ray beamlines and modernisation of the user support laboratories
- Ambitious instrumentation programme, and an intensified 'big data' strategy, designed to exploit the enhanced brilliance, coherent flux and performances of the new X-ray synchrotron source

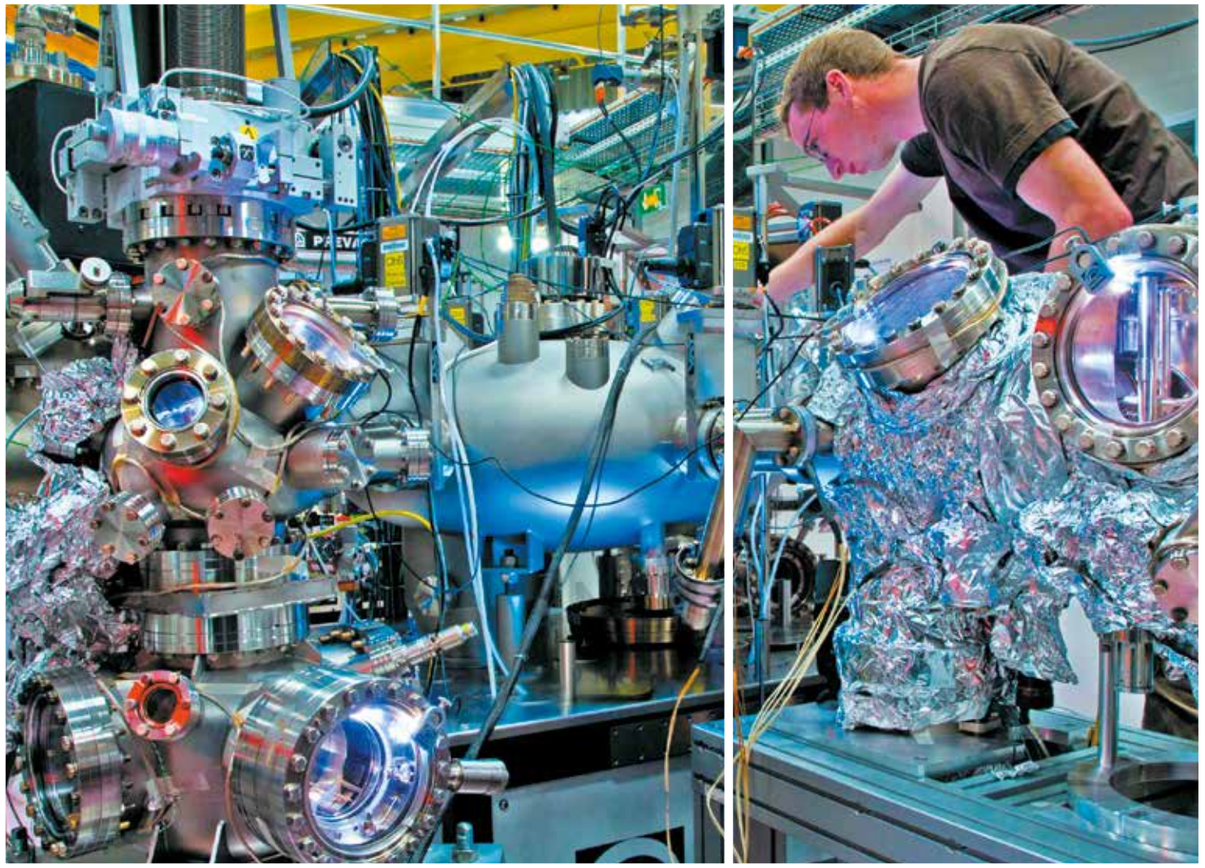
The challenges of this ground-breaking programme:

To consolidate the position of the ESRF as a global leader by conceiving a new generation of synchrotron light sources, even more intense, coherent and stable, while reutilising 90% of the existing infrastructure

To push back the boundaries of X-ray science and to offer a new perspective on the nanoworld

To stimulate innovation and improve the competitive edge of European industry

To provide answers to the great technological, economic, societal and environmental challenges of the 21st century by deploying unrivalled methods for exploring matter



A two-phase programme

This programme, with a total investment of 330 million euros, is implemented in two phases:
Phase I (180 million euros), initiated in 2009 and to be completed by the end of 2015, is a success story among the projects appearing in the European Strategy Forum on Research Infrastructures (ESFRI) roadmap.
This initial phase has facilitated:

- the construction of 19 new generation experimental stations, to explore the nanoworld
- the creation of a new ultra-stable experimental hall, covering an area of 8,000 m²
- the improvement and refurbishment of most of the cutting-edge scientific equipment and accelerator infrastructure

Finally, Phase I has allowed the ESRF accelerator scientists to conceive and design a novel ultra-bright synchrotron source to be located in the present storage ring tunnel with performances 100 times superior to the present ESRF source and other synchrotrons worldwide. Close to completion, Phase I is on time and within budget.

Phase II (150 million euros) will cover the period 2015-2022.
This represents a real technological challenge: to complete, within a limited period and based on a pre-existing structure, with minimal disruption of the ongoing users' programme, the shutdown, dismantling and installation of a new synchrotron source.

There are four deliverable in Phase II:

- a new storage ring, with the construction of new magnetic components to increase brilliance and coherence
- the construction of new state-of-art beamlines
- an ambitious instrumentation programme, with particular focus on high-performance detectors, and
- an intensified 'big data' strategy, designed to exploit the enhanced brilliance, coherence flux and performances of the new X-ray synchrotron source

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THE UPGRADE PROGRAMME PHASE II: TO DESIGN A NEW GENERATION OF SYNCHROTRONS

A new design for the storage ring

With a circumference of 844 metres, the storage ring of the ESRF consists of 32 cells, comprising very precise sequences of sophisticated components such as magnets, vacuum chambers and position monitors. The role of these components is to monitor and control the trajectory and the properties of the electrons travelling inside the storage ring at a speed a whisker below the speed of light. On the main objectives of the Upgrade Programme Phase II is to replace these 32 cells, inside the existing infrastructure, with new arcs whose more complex sequencing will make it possible to create an X-ray source of very low emittance (with less divergence and smaller in size).

Among other items, each of the 32 cells will comprise, over a length of 27 metres:

- 14 vacuum chambers (currently 7)
- 31 magnets (currently 19)
- 10 compensating magnets and 10 position monitors

“In relation to the work completed over the past decade concerning the constant improvement of synchrotron-generated light, a quantum jump was required. The ESRF accelerator scientists found an innovative solution which will boost the brilliance of the X-rays and their coherence by a factor of 100. Many technological challenges lay ahead, but the most critical one is to install a new storage ring inside the existing structure, 90% of which will be reused. The unrivalled properties of this new light source will transform the facility into a unique instrument, opening up new perspectives for X-ray science in many fields of fundamental and applied research.”

Harald REICHERT and Jean SUSINI
Research Directors at the ESRF

THE UPGRADE PROGRAMME PHASE II: TO DESIGN A NEW GENERATION OF SYNCHROTRONS 2

The technological challenge

• The shutdown and dismantling of the existing accelerators and the installation of a new synchrotron source, to be completed within a limited period with minimal disruption of the ongoing user programme.

The scientific challenge

• To boost the performance of the storage ring so as to increase the brilliance and coherence of the X-ray source by a factor of 100
• To write a new chapter in X-ray science and to open a new window on the nanoworld

The challenges

Compared with third-generation synchrotrons, Phase II will enable the ESRF to produce X-ray beams with properties that have never been obtained using a synchrotron. This qualitative leap forward will not only open up new fields of investigation for fundamental research, it will also stimulate innovation by permitting improved analysis and understanding of materials with the possibility to efficiently reach spatial resolution at the nanometre level, enabling unprecedented characterisation and understanding of materials and living matter. This exploration of material is an essential prerequisite for understanding the composition of the world around us and for developing new sustainable materials, innovative industrial products and human health treatments in response to the major challenges confronting our society.

The potential fields of application are many:
- nanoscopy for the creation of new materials
- science at extreme conditions (planetary science, technological materials)
- multidimensional (3D, time, chemical, etc.) nano-imaging
- structural biology and health sciences
- materials science
- nanotechnologies
- environmental and energy sciences, etc.

Today the ESRF is ready to conduct such a project within acceptable costs and deadlines with the unique concentration of skills and the expertise of its staff and drawing on its successful experience with Phase I, completed on time and within budget.

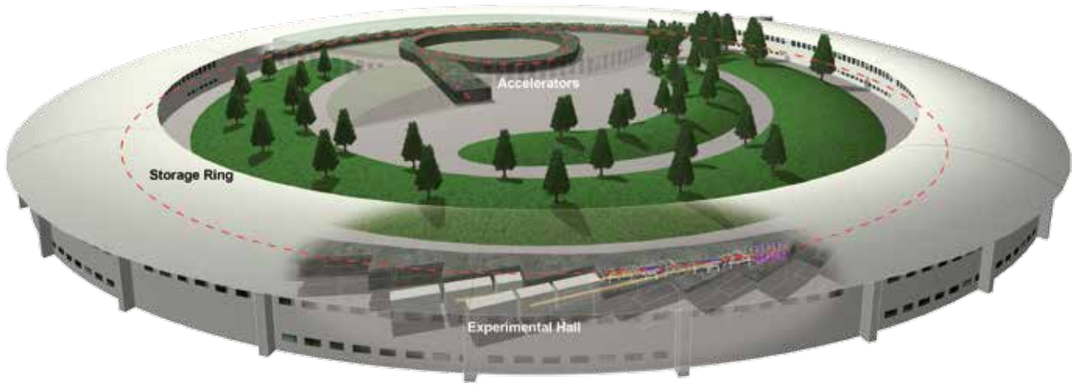
Key numbers and timetable

Numbers

For the new storage ring
- 128 girders (around 800 Tons of steel) for the storage ring
- more than 1000 magnets of various kinds
- more than 900 m of vacuum chambers for electron and photon beam
- 450 copper photon absorbers

90% of the existing infrastructure will be reused

20% less energy needed and consumed by all the accelerator systems



Timetable: 2015-2022

- 2015-end 2018: procurement and pre-assembly of the new storage ring
- 2019-june 2020: pause in the users' programme for seventeen months to dismantle the existing accelerator, and to assemble and commission the new one
- June 2020: restart of the users programme

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ESRF IN BRIEF

The ESRF, (the European Synchrotron Radiation Facility), a very large infrastructure for international research, is the world's most intense X-ray source. The X-rays it generates are 100,000 billion times more powerful than hospital radiographic equipment. Functioning like a giant microscope, with its extremely brilliant light the ESRF provides unrivalled opportunities for the exploration of materials and living matter in a very wide variety of fields, ranging from the chemistry and physics of materials to archaeology and cultural heritage, together with structural biology and medical applications, the sciences of the environment and the sciences of information and nanotechnologies.

As a facility for fundamental research, available for applied and industrial research, the ESRF offers scientists from around the world an extremely powerful and constantly-evolving tool, equipped with 43 specialised experimental stations. The strength of the ESRF also resides in its ability to bring together, within the same installation, interdisciplinary teams of world-class researchers, engineers and technicians.

Key numbers

Budget, staff, governance

- 21 partner nations, including 13 Member States and 8 Associate countries
- Annual budget: 100 million euros
- 630 members of staff of 40 different nationalities

Global scientific sphere of influence

- 6,500 individual visits every year, including 4,000 users
- 2,000 proposals received for experiments per year: 900 accepted, realisation of 1,550 experimental sessions
- 30% of the research involves industrial developments

Global scientific excellence

- First place for scientific production
- Second place for number of users
- Worldwide reputation for the quality and reliability of the service offered to users
- ESRF users include 4 Nobel prize-winners
- 25,166 publications in peer-reviewed journals during the period 1994-2014
- around 30 articles in *Nature and Science* every year
- around 1,900 publications per year, equivalent to about 5 every day!

ESRF IN BRIEF 3

The ESRF, a model of international cooperation

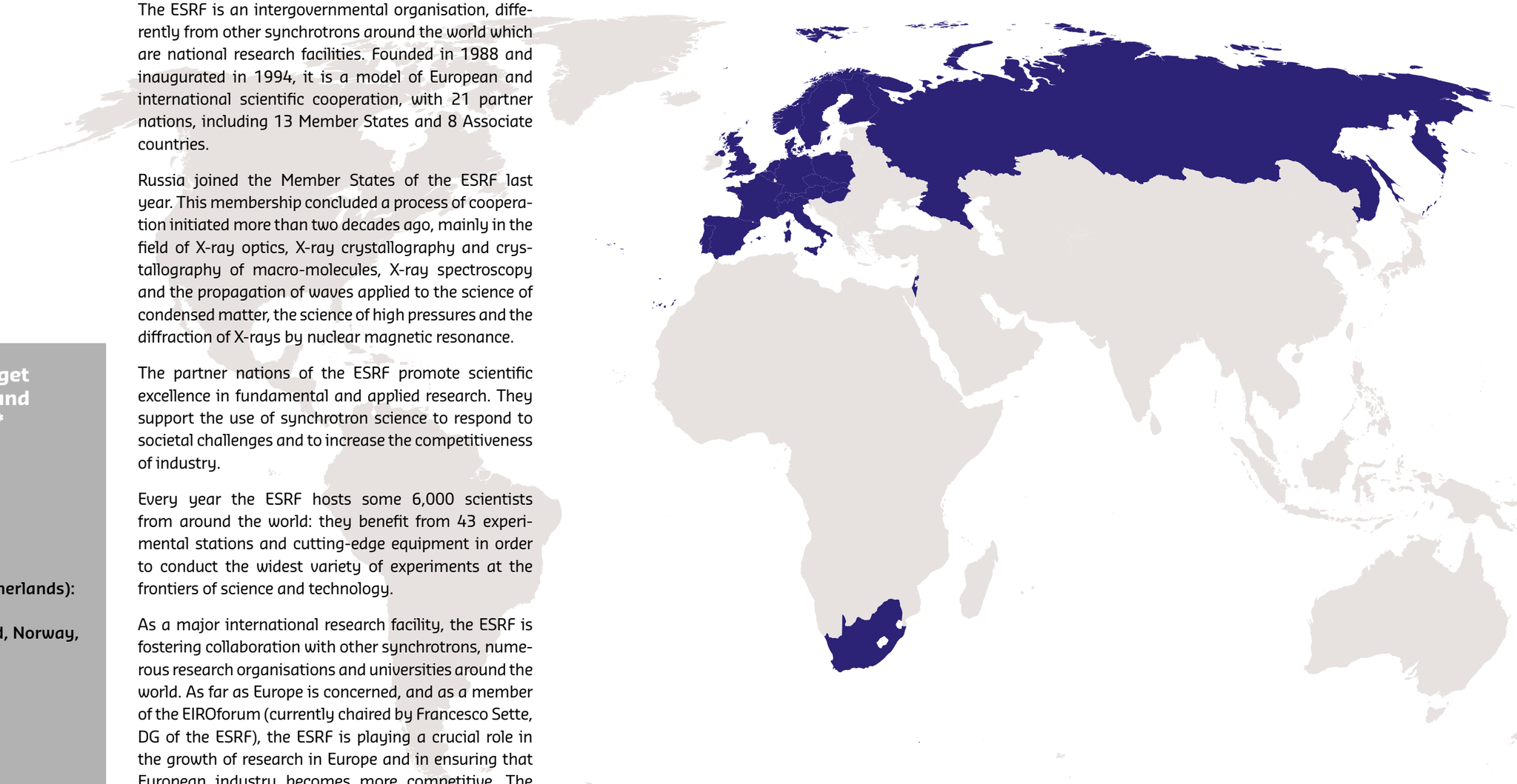
The ESRF is an intergovernmental organisation, differently from other synchrotrons around the world which are national research facilities. Founded in 1988 and inaugurated in 1994, it is a model of European and international scientific cooperation, with 21 partner nations, including 13 Member States and 8 Associate countries.

Russia joined the Member States of the ESRF last year. This membership concluded a process of cooperation initiated more than two decades ago, mainly in the field of X-ray optics, X-ray crystallography and crystallography of macro-molecules, X-ray spectroscopy and the propagation of waves applied to the science of condensed matter, the science of high pressures and the diffraction of X-rays by nuclear magnetic resonance.

The partner nations of the ESRF promote scientific excellence in fundamental and applied research. They support the use of synchrotron science to respond to societal challenges and to increase the competitiveness of industry.

Every year the ESRF hosts some 6,000 scientists from around the world: they benefit from 43 experimental stations and cutting-edge equipment in order to conduct the widest variety of experiments at the frontiers of science and technology.

As a major international research facility, the ESRF is fostering collaboration with other synchrotrons, numerous research organisations and universities around the world. As far as Europe is concerned, and as a member of the EIROforum (currently chaired by Francesco Sette, DG of the ESRF), the ESRF is playing a crucial role in the growth of research in Europe and in ensuring that European industry becomes more competitive. The ESRF, the EMBL (European Microbiology Laboratory) Grenoble outstation and the ILL (Institut Laue-Langevin) and the IBS (Institut de Biologie Structurale, CEA, CNRS, UJF), which are located in the European Photon and Neutron (EPN) Science Campus in Grenoble, share their skills and expertise to create new scientific opportunities to the benefit of the scientists from everywhere in Europe and worldwide.



Contribution to the budget (in %) by the Members and Associates of the ESRF *

13 Member States:

- **France: 27.5%**
- **Germany: 24%**
- **Italy: 13.2%**
- **United Kingdom: 10.5%**
- **Russia: 6%**
- **Benesync (Belgium, the Netherlands): 5.8%**
- **Nordsync (Denmark, Finland, Norway, Sweden): 5%**
- **Spain: 4%**
- **Switzerland: 4%**

8 Associate countries:

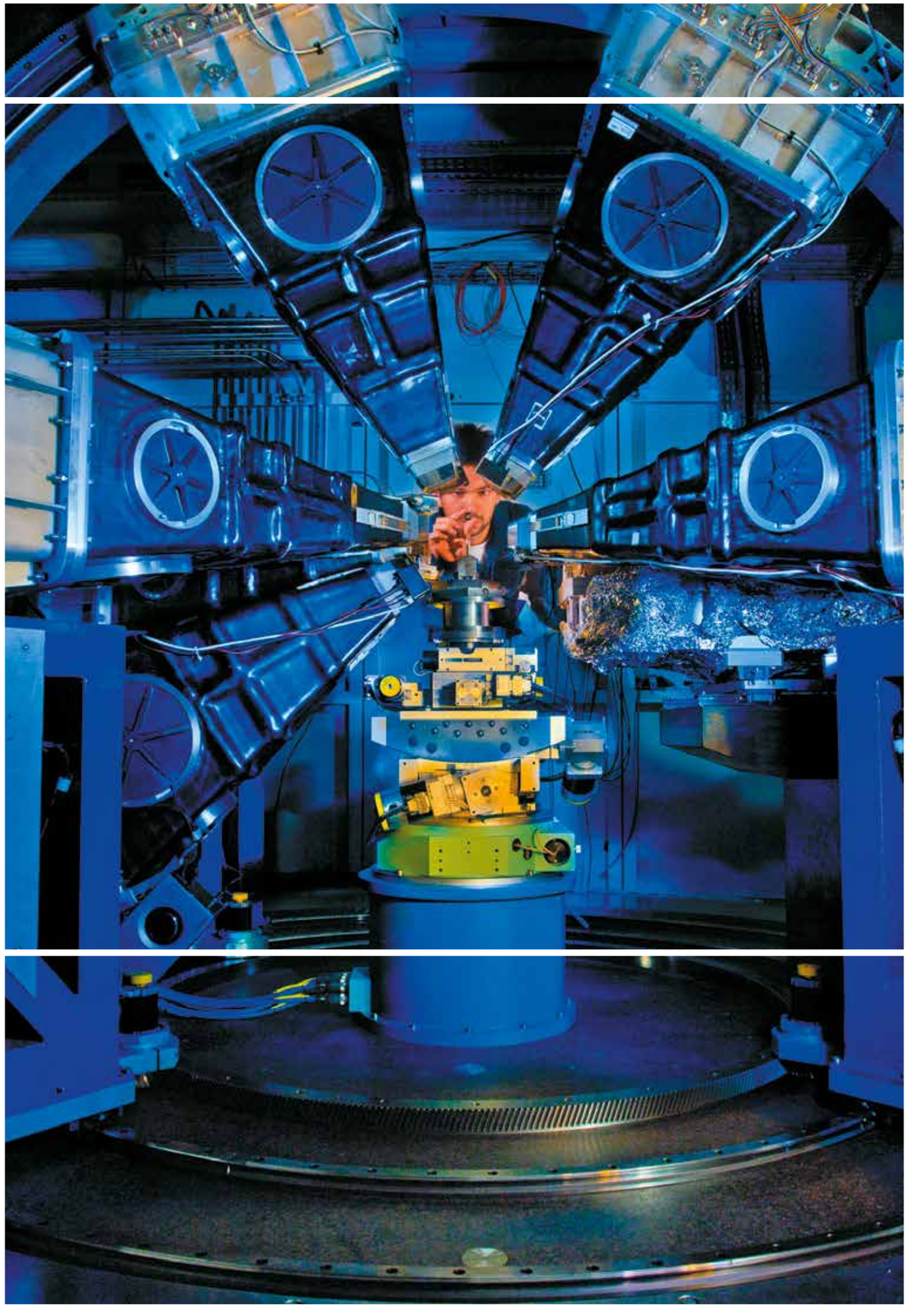
- **Israel: 1.5%**
- **Austria: 1.3%**
- **Centralsync (Czech Republic, Hungary, Slovakia): 1.05%**
- **Portugal: 1%**
- **Poland: 1%**
- **South Africa: 0.3%**

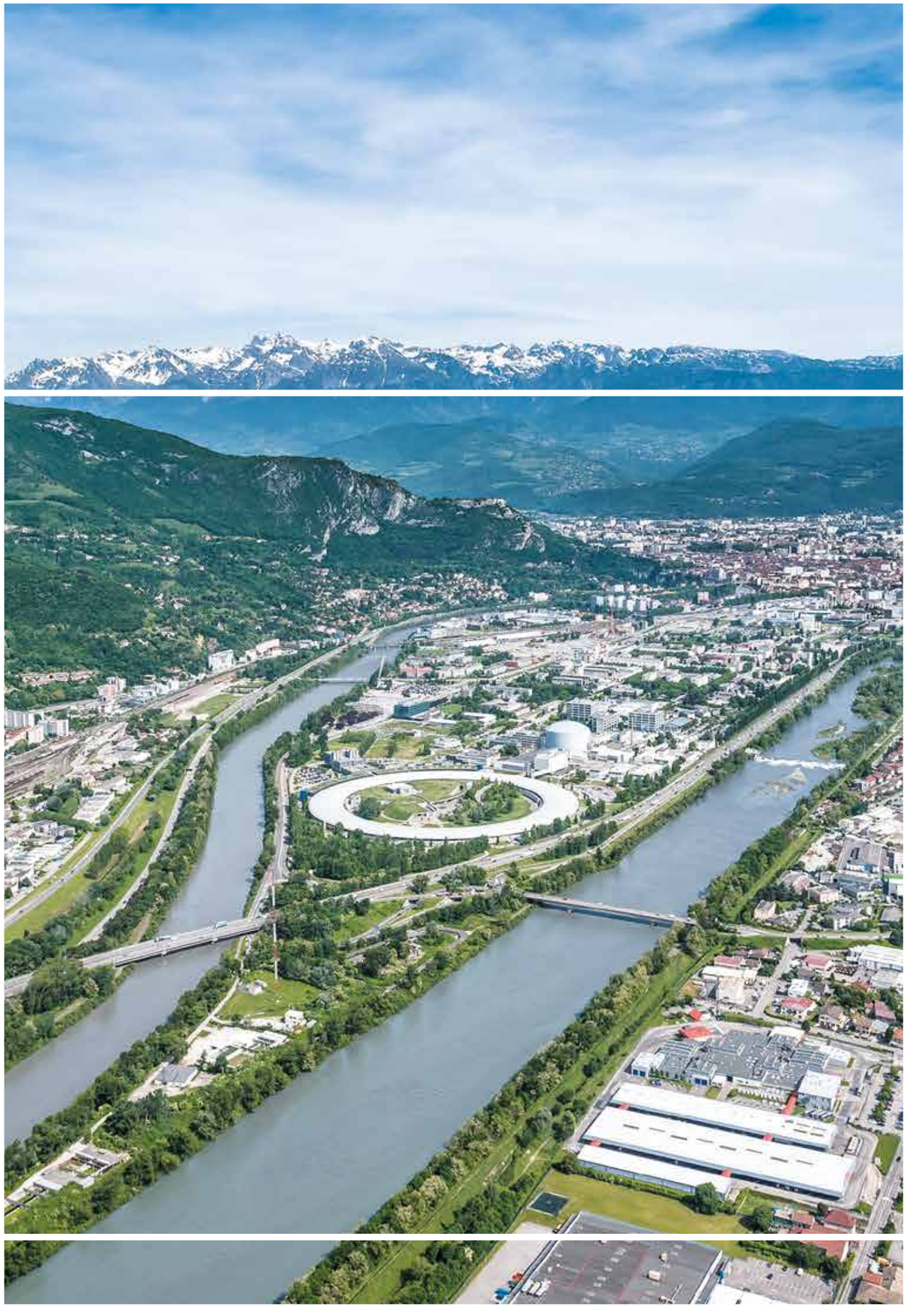
* The legal status of the ESRF is a private civil company subject to French law.

The ESRF, at the boundaries of science and innovation

What is the composition of our planet? What do we know about life processes? How can the properties of matter be explained? One day, will it be possible to fight cancer more effectively or to develop more targeted medicines? How better to use renewable materials? Can we invent new electronic components? How to combat pollution more effectively? The majority of these questions can be solved through an in-depth knowledge of the detailed structure of matter, at the atomic and molecular levels. These are some of the challenges of the research conducted at the ESRF.

The extremely brilliant light generated by the ESRF provides unrivalled opportunities for scientists all over the world in the exploration of materials and living matter in a very wide variety of fields, ranging from the chemistry and physics of materials to archaeology and cultural heritage, together with structural biology and medical applications, the sciences of the environment and the sciences of information and nanotechnologies.





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