

ESRF-EBS: A new generation of synchrotron for Europe

More brilliant than ever, light is back at the ESRF, the European Synchrotron in Grenoble. On 25 August 2020, a brand-new generation of high-energy synchrotron will open its Extremely Brilliant Source (EBS) of X-rays to the international scientific community. With X-ray performances multiplied by 100 compared to before, ESRF-EBS hails a new era for X-ray science in the 3D exploration of matter at all scales and down to the atomic scale. ESRF-EBS will contribute to tackling global challenges in key areas such as health, environment, energy and new industrial materials, and to unveiling hidden secrets of our natural and cultural heritage through the non-destructive investigation of precious artifacts and palaeontological treasures. A shining example of international cooperation, EBS has been funded by 22 countries joining forces to construct this innovative and world-unique research infrastructure with an investment of 150 million euros over 2015-2022.

A new generation of high-energy synchrotron

"A dream machine is becoming a reality," says Pantaleo Raimondi, Director of the Accelerator & Source division at the ESRF and inventor of the ESRF-EBS concept. *"In 2013, EBS was still a concept imagined on paper. Today, thanks to the expertise and enthusiasm of the ESRF teams, we are preparing to restart the scientific programme. I am excited to see the science that will result!"*

"This is a moment of pride for the whole of the synchrotron community," added Francesco Sette, Director-General of the ESRF. *"With the opening of this brand-new generation of high-energy synchrotron, the ESRF continues its pioneering role to provide an unprecedented new tool for scientists from our 22 partner countries and the world to push back the frontiers of science and address vital challenges facing our society today, such as health, environment and energy."*

"The fact that EBS has obtained the nominal beam parameters in such a short space of time is incredible," said Caterina Biscari, Chair of LEAPS, the League of European Accelerator-based Photon Sources, a partnership of 16 light sources across Europe, including the ESRF. *"It sets an example to all the other facilities planning to upgrade to fourth-generation sources."*

On 10 December 2018, after having paved the way for modern, third-generation synchrotron sources worldwide, and after 26 years of loyal service, one of the highest-performing X-ray sources in the world was shut down for 20 months. The aim: to replace it with a new source of light based on a revolutionary new concept and even more brilliant than before: ESRF-EBS.

Teams took three months to dismantle the ESRF's historic storage ring (disconnecting 200 km of cables and removing 1720 tonnes of equipment) and nine months to install the new machine in the 844-m-circumference tunnel, before carrying out the precise alignment of 10,000 innovative technological components to a relative accuracy of less than 50 microns – around half the width of a human hair – over kilometre distances.

On 28 November 2019, electrons were injected into the new EBS storage ring for the first time. Commissioning followed and, by 14 March, just before the site closed due to the COVID-19 pandemic, the machine operation parameters necessary to open EBS were reached, five months ahead of schedule. Thanks to this intensive work, EBS is now ready to be opened to the scientific community, as planned, on 25 August 2020.

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The quest for brilliance, physics' Holy Grail

Since the 1970s, thanks to an acceleration in technological progress, several new generations of synchrotrons have been developed, each one improving the brilliance and coherence of the X-rays produced compared to its predecessor, each one pushing the frontiers of what is possible in the exploration of matter.

When it opened in 1994, the ESRF was the world's first third-generation synchrotron light source, with X-ray performances 100 to 1000 times higher than the synchrotrons of the day. Today, the ESRF continues its pioneering role by opening the first fourth-generation high-energy synchrotron, improving X-ray performances of brilliance and coherence once again by a factor of 100.

This new concept, based on innovative technology, paves the way for a new generation of synchrotrons around the world. Indeed, several upgrade projects based on EBS are already in development worldwide.

A new era for X-ray science and the exploration of matter

EBS will provide new tools for the investigation of the structure of living matter and materials at the atomic scale, with applications in numerous fields including health, energy, environment, new sustainable materials, and also cultural heritage and paleontology.

Imagine being able to scan a human organ at extremely high resolution to better understand the process of infection, such as in diseases like COVID-19. Or the ability to map the human brain at the synapse level, with important implications for neuro-degenerative disease and emerging artificial neural network architecture based technologies. How about being able to track the presence in soil of nanoparticles from our everyday products at doses that were, until now undetectable, to better evaluate their potential toxicity for the environment? And being able to carry out a virtual autopsy of a complete mummy up to the cellular level and thus to enrich our knowledge of ancient civilisations? Or being able to better identify the chemical reactions at the origin of the degradation of artistic masterpieces to help preserve humanity's natural and cultural heritage.

Such capabilities will enable scientists to better understand life and the world around us, and to make the invisible visible.

The EBS's extremely brilliant light has already been made available for priority research on COVID-19 in two fields: structural biology to understand the functions and interactions of the virus with the host cell, with the aim to contribute to the development of vaccines or effective antivirals, and the use of 3D imagery for lung scanning in order to understand the effects of coronavirus on organs, especially during the infection phase.

A bright example of international cooperation

More than ever science needs to be international and global to tackle the complex challenges facing our society. Since its inception in 1988, the ESRF has driven synchrotron science worldwide. Nations from Europe, and then from other parts of the world, decided to share the dream of creating unique opportunities for new knowledge at the service of the whole scientific community, and thus humanity. Driven by scientific and technological excellence, ready to take and share the risk of the unknown, recognising the value of international cooperation beyond discipline, gender, language and culture, the ESRF partner countries – with the successful within-budget and on-time realisation of the EBS programme – have set a new standard in international collaboration.