ESRF UPGRADE PROGRAMME REACHES HALFWAY MARK

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In 2012, the ESRF reached the peak activity of the first phase of its Upgrade Programme. This included a 5-month shutdown until May 2012, the first time ever in 18 years that the user operation was shut down for such an extended period of time.

The first new beamlines are now available for user operation, and many more will become operational until the end of Phase I of the upgrade in 2015. Remarkably, the performance of the ESRF for its users did not drop significantly despite a period of heavy works. The X-ray source performs better than ever, with record values for the mean time between failure and availability. Although the number of hours of user operations is slightly lower than in the past years, due to the construction-related shutdown periods, the interest in the ESRF remains high, and the number of proposals did not decrease, on the contrary!

Upgrade Beamlines

Eight Upgrade Beamline Projects are a core deliverable of the Upgrade Programme. These are now all under development, and most of them are already under construction. Together, the eight Upgrade Beamline Projects actually comprise 11 different new beamlines with 15 independently operable end stations (Figure 1).

In the following, short descriptions are given of these eight projects, including the opening dates of the end stations for users and whom to contact for any enquiry:

ID01 Diffraction imaging for nano-analysis

Long beamline for nano-X-ray diffraction across a wide energy range (2.2 – 50 keV), offering coherent imaging of individual nanostructures as well as basic surface diffraction and small-angle scattering. Combines X-ray diffraction with atomic-force microscopy to allow investigations of the structure-function relationship at the nanoscale. Targets the study of properties of device-like structures in unprecedented detail.

Open late 2014, scientist in charge: Tobias Schulli, schulli@esrf.fr.

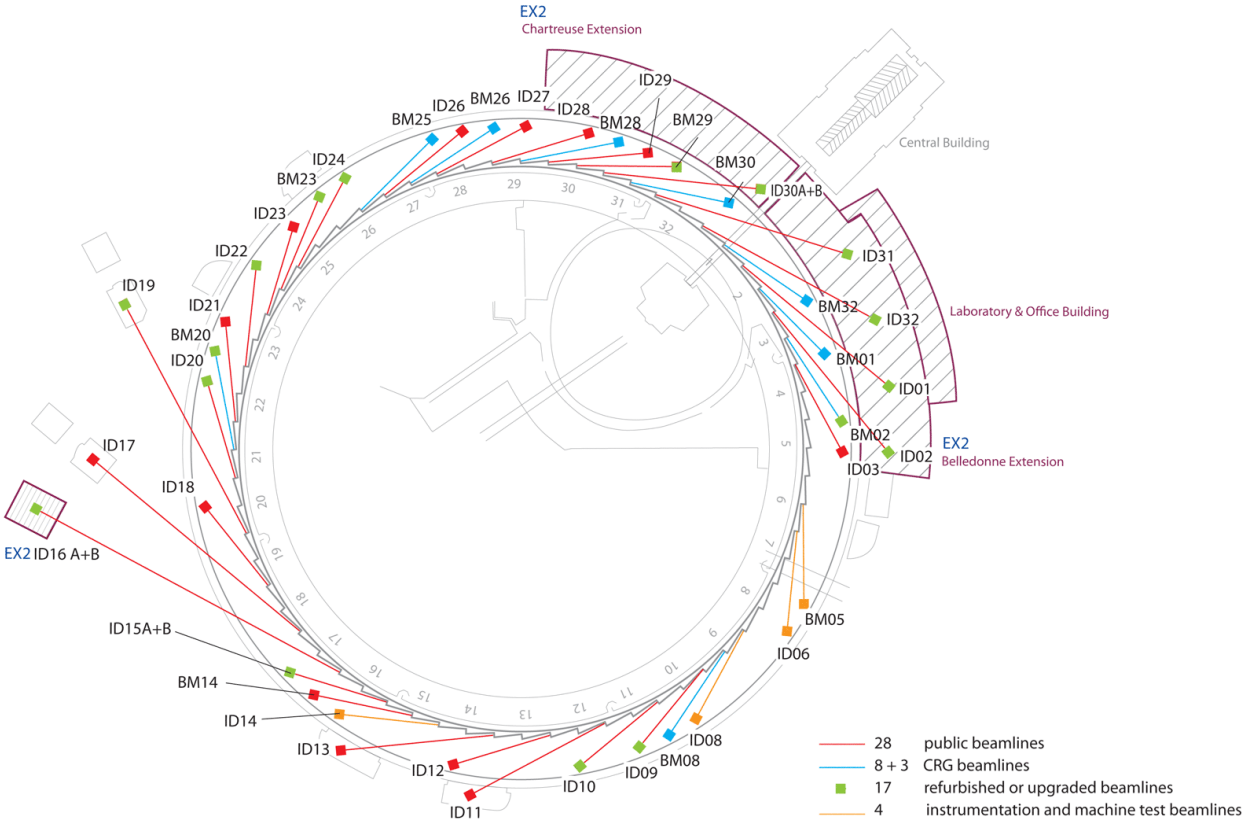

Figure 1: ESRF experimental hall.

ID31 High-energy beamline for buried interface structures and materials processing (previously ID15)

Long beamline covering energies 30 – 150 keV for the study of working devices *in situ*, with new optics allowing the beam size to be reduced to 200 nm at the push of a button. The smaller spot size will allow users to study less perfect, more realistic, interfaces to understand the interplay between microscopic material properties and macroscopic device performance — in particular concerning advanced materials for fuel cells, organic solar cells, rechargeable batteries and catalytic materials.

Open early 2015, scientist in charge: Veijo Honkimäki, honkimak@esrf.fr.

ID16 Nano-imaging and nano-analysis (previously ID22)

Long, high-brilliance beamline providing nanofocused beams for two end stations. Operated in a cryogenic environment, the nano-imaging end station will focus hard X-rays at specific energies to a spot size as small as 15 nm and combine fluorescence analysis and nanotomography. The nano-analysis end station will provide a monochromatic beam tunable in a large energy range, offering a multianalysis nanoprobe for spectroscopic studies. ID16 will focus on biomedical research, for instance allowing subcellular processes to be studied, as well as environmental sciences, energy and nanotechnology.

Open February 2014, scientist in charge: Peter Cloetens, cloetens@esrf.fr.

ID20 Inelastic hard X-ray scattering for electronic spectroscopy (previously ID16)

Two end stations offering a spectroscopic tool with all the advantages of a hard X-ray probe — bulk information, high-penetrating power and elemental and spin sensitivity — designed to enhance the ESRF's inelastic scattering programme. The upgrade will decrease the size of the beam from around 100 microns to 10 microns, allowing experiments in extreme conditions, for example at very high pressure. The energy range will also increase from 6 – 10 KeV to 5 – 20 KeV, enabling resonant experiments at a large number of absorption edges with increased compatibility with more complex sample environments. Finally, more luminous spectrometers will broaden the scientific impact of inelastic X-ray scattering.

Open March 2013, scientist in charge: Giulio Monaco, gmonaco@esrf.fr.

ID32 Soft X-rays for magnetic and electronic spectroscopy (previously ID08)

State-of-the art facility for soft X-ray absorption spectroscopy and very high-energy resolution resonant inelastic X-ray scattering, with sophisticated sample environments and tunable X-ray beam sizes ranging from microns to hundreds of microns. The beamline will provide new facilities for users to study the electronic and magnetic properties of materials, offering magnetic dichroism techniques and soft resonant inelastic X-ray scattering to meet the demands of an expanding user community.

Open August 2014, scientist in charge: Nick Brookes, brookes@esrf.fr.

ID02 / ID09 Time-resolved experiments (previously ID02 / ID09B)

Two independent beamlines. The long beamline ID02 will extend SAXS to ultra-small (microradian) angles with sub-millisecond time resolution, pushing the technique's applicability to systems ranging from colloidal plasmas to highly self-assembled biomimetic systems. ID09 is dedicated to time-resolved diffraction and scattering, with picosecond laser pulses initiating structural changes in the sample that can then be probed with ultrashort X-ray pulses.

Open: ID02 April 2014, scientist in charge: Theyencheri Narayanan, narayan@esrf.fr
ID09 operational, scientist in charge: Michael Wulff, wulff@esrf.fr.

ID30/BM29 Massively automated sample selection integrated facility for macromolecular crystallography

A unique resource based on second-generation automation for macromolecular crystallography experiments, designed to help structural biologists tackle ever more ambitious projects, such as complex membranes. The hub of the project is a sample-evaluation and sorting facility (MASSIF), from which the most suitable crystals for data collection will be distributed to the best suited of seven end stations (MASSIF-1/-2/-3, ID23-1/-2, ID29 or ID30B). Such screening is vital to cope with the problem of inter- and intra-sample variations in modern macromolecular crystallography experiments.

Open: BM29A June 2012; ID30A May 2013; ID30B May 2014, scientist in charge: Christoph Mueller-Dieckmann, christoph.mueller_dieckmann@esrf.fr.

ID24/BM23 Time resolved and extreme conditions X-ray absorption spectroscopy (previously ID24/BM29)

High-brilliance energy dispersive X-ray absorption spectroscopy (EDXAS) allows users to study the local and electronic structure of matter in real time and *in situ*; the behaviour of matter under extreme pressures and temperatures, such as those in the Earth's core, or the structure-function relationship in industrially-relevant catalysts. Two independent end stations (EDXAS_S "small spot" and EDXAS_L "large spot") on ID24 combined with the general

purpose EXAFS station on BM23 will permit X-ray absorption spectroscopy in sample volumes 20 times smaller and with time resolution a 1000 times better than before.

Open: BM23 since November 2011; EDXAS_S May 2012; EDXAS_L Sep 2012, scientist in charge: Sakura Pascarelli, sakura@esrf.fr.

Beamline Refurbishments

During the Upgrade, every ESRF beamline will undergo at least some form of refurbishment, and those with only light improvements will be candidates for Phase II of the upgrade beginning in 2015. The national "CRG" beamlines, which include the Italian GILDA beamline, do not receive ESRF funding, but they stand to benefit from improvements to the X-ray source, sample environments and larger experimental halls.

Major refurbishments to the beamlines ID19 and ID10 are now nearing completion, and they will boost ESRF's imaging, soft-matter and interface science as of the summer of 2012:

Today, palaeontology represents more than 35% of the ID19 microtomography proposals. After more than ten years of operation, ID19 is currently undergoing an in-depth refurbishment with palaeontology as the science driver, but benefiting also other research areas such as materials science, engineering, environmental sciences and biology. ID19 will provide a high-flux pink beam allowing multi-scale imaging at sub-micron resolution of objects measuring up to 40 cm across.

The refurbishment will be complete by spring 2013. The neighbouring ID17 beamline will be equipped with a new sample stage for large fossil scanning plus a refurbished monochromator for higher-energy operation and eventually a new detector. Contacts: Paul Tafforeau, paul.tafforeau@esrf.fr (ID19) and Alberto Bravin, bravin@esrf.fr (ID17).

In parallel, the ID10 beamline complex — previously known as the Troika I, II and III beamlines — will restart in June 2012 after an in-depth refurbishment under the new name "soft interfaces and coherent scattering" (SICS). ID10A/C and ID10B have been transformed into one beamline with two end stations working in time-sharing mode. One station (SICS-CS) will be devoted to X-ray photon correlation spectroscopy and coherent X-ray diffraction imaging, while the other (SICS-LSIS) will offer liquid surfaces and interfaces scattering based on X-ray reflectivity and grazing incidence scattering. Each station will benefit from independent optics and instrumentation optimised for each of the techniques, and will be served by two different silicon monochromators. Contacts: Oleg Konovalov, konovalo@esrf.fr (SICS-LSIS) and Yuriy Chushkin, yuriy.chushkin@esrf.fr (SICS-CS).

Instrumentation and Data Handling

Developing state-of-the-art instrumentation is another pillar of the Upgrade Programme. Driven by the projects for new beamlines, the need for new technologies was identified in the fields of X-ray mirror engineering, diamond technologies, nanofocussing optics, pixel detectors, on-line data analysis and high-rate data collection.

Handling the massive flux of data coming in particular from the latest generation of 2D detectors is a challenge which requires a coordinated approach between different groups at the ESRF. Today, the petabyte has become the standard unit for data-intense facilities like the LHC at CERN (15 petabytes/year) or the ESRF (several petabytes/year).

Work has started to optimise the integration of the data flow from the detectors into the ESRF IT infrastructure in order to minimise bottlenecks between data collection and the actual data analysis. Already in 2011, a new data centre was inaugurated, equipped with state-of-the-art file servers capable of storing almost 1 petabyte of data, a tape-based archiving facility of several petabytes, computing clusters with a peak performance of 15 teraflops and an extensive 10 Gbit/s Ethernet infrastructure. This can easily be extended thanks to pre-installed power, cooling and networking resources, allowing a flexible response to changing demands of the users for storage, data analysis capacity and data backup, for many years to come. Plan of the ESRF experimental hall (Figure 1) showing the location of the beamlines at the end of phase I of the ESRF Upgrade Programme. Refurbished and Upgraded beamlines are marked in green; new buildings are outlined in red (Image credit: ESRF/M. Collignon)

View of construction works for the Belledonne experimental hall extension area, March 2012 (Figure 2). About 8500 m^2 of new experimental halls, laboratory and office space is being created. The buildings are scheduled for completion by June 2013. (Image credit: ESRF/C. Argoud).

Inauguration of Upgrade Beamline ID24. Ribbons were cut during the inauguration ceremony on 11 November 2011 to mark the opening of two new beamline branches (Figure 3). Left: High-pressure / extreme conditions branch. From left to right: Francesco Sette, ESRF Director General, Sakura Pascarelli, Scientist in charge of ID24, Harald Reichert, ESRF Research Director. Right: Chemistry branch. From left to right: Michel van der Rest, vice-chairman ESRF Council, Geneviève Fioraso, Députée de l'Isère et Adjointe au Maire chargée de l'Economie, l'Emploi, l'Université, la Recherche, Rafael Abela, Chairman ESRF SAC. (Image credit: ESRF/C. Argoud).

Figure 2: construction works for the Belledonne experimental hall.

Figure 3: Inauguration of Upgrade Beamline ID24.