European Synchrotron Radiation Facility

The Upgrade of the ESRF PHASE I
ESRF Upgrade Programme
Purple Book (September 2007)

Key Objectives & Deliverables

• Eighteen new and upgraded experimental stations (beamlines)
• Delivery of enabling technologies
• Enhancement of the X-ray source
• Construction of 21,000 m2 of additional space.
• Development of collaborations and partnerships with academia, other synchrotrons, and industry
Science drivers of the Upgrade Programme of the ESRF
ESRF Upgrade Programme
Phase I and Phase II

Phase I
19 upgraded or refurbished BLs
Accelerator and source upgrade
Construction programme

2009

Current

MTSP

2015

Phase II
New storage ring
4 new BLs
Enabling technology

2015

2020
Five Science Highlight Areas – 8 approved UPBLs

- **UPBL10**
  - ID30/BM29
  - Structural/functional biology, and soft matter

- **UPBL11**
  - ID24/BM23
  - Science at extreme conditions

- **UPBL12**
  - ID02
  - Pump-and-probe experiments and time-resolved science

- **UPBL4**
  - ID16
  - X-ray imaging

- **UPBL7**
  - ID32
  - Nanoscience and nanotechnology

- **UPBL1**
  - ID01
  - New, better science

- **UPBL6**
  - ID20
  - Powder diffraction

- **UPBL9a**
  - ID09TR
  - High pressure

- **UPBL9b**
  - ID31
  - Powder diffraction

- **UPBL2**
  - ID31
  - X-ray imaging

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  - ID30/BM29
  - Structural/functional biology, and soft matter

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- **UPBL2**
  - ID31
  - X-ray imaging
TECHNOLOGY DEVELOPMENT FOR THE BEAMLINES

Beamline Control & Data Analysis
- Modernization of the BL control (long shut-down)
- On-line data Analysis
- Computing infrastructure

High Precision Engineering
- Consolidation and further developments of expertise in Mechatronics
  - Advanced modeling tools
  - Advanced control methods
  - in-situ metrology

X-Ray Optics
- Preservation of the transverse beam coherence
  - Manufacturing methods
  - New optical metrology tools
  - New simulation tools

X-Ray Detectors
- 2D Detectors combining temporal and spatial resolution
  - Silicon hybrid pixel detectors
  - CMOS Monolithic Active Pixels Sensors (MAPS)
### Implementation of UPBLs

<table>
<thead>
<tr>
<th>UPBL</th>
<th>Old Sector</th>
<th>New Sector</th>
<th>Application</th>
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<tbody>
<tr>
<td>UPBL1</td>
<td>ID01</td>
<td>ID01</td>
<td>Diffraction for Nano-Analysis</td>
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<tr>
<td>UPBL2</td>
<td>ID15</td>
<td>ID31</td>
<td>High Energies for interfaces and materials processing</td>
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<tr>
<td>UPBL4</td>
<td>ID22</td>
<td>ID16</td>
<td>Nano-Imaging and Nano-Analysis</td>
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<tr>
<td>UPBL6</td>
<td>ID16</td>
<td>ID20</td>
<td>Inelastic X-ray Scattering</td>
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<tr>
<td>UPBL7</td>
<td>ID08</td>
<td>ID32</td>
<td>Soft X-rays/nano-magnetic &amp; electronic spectrosc.</td>
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<tr>
<td>UPBL9a</td>
<td>ID02</td>
<td>ID02</td>
<td>Time-resolved ultra small angle scattering</td>
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<tr>
<td>UPBL9b</td>
<td>ID09TR</td>
<td>ID09</td>
<td>Pump-probe and time-resolved experiments</td>
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<tr>
<td>UPBL10</td>
<td>ID14</td>
<td>ID30</td>
<td>Massively Automated Sample Selection Integrated Facility</td>
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<tr>
<td>UPBL11</td>
<td>ID24/BM29</td>
<td>ID24/BM23</td>
<td>Time-resolved and Extreme conditions XAS</td>
</tr>
</tbody>
</table>

+ 2 moving BLs (ID15 complex & ID31) + 2 refurbished BLs (ID10 & ID19)
UPBL11 – ID24
Time-resolved and Extreme Conditions XAS
MV2: 3 x 3 µm²

Source

Sample 64.7 m

MV2 64.48 m

Poly-S 64.0 m

Sample 64.7 m

Poly-L 55.0 m

MV2 optional 55.48 m

MV1 28.5 m

MH1S

MH1L 31.0 m

Laue polychromator: 2013

EDXAS_S
small beam for extreme conditions science

EDXAS_L
large beam for chemistry program

Optics/Polychr. Hutches

new XH Ge strip detector delivery summer 2013
UPBL6 – ID20

Inelastic Scattering
Key Parameters
- ENERGY RANGE: 5 – 20 KeV
- ENERGY RESOLUTION: 1eV to 25 meV
- FOCAL SPOT SIZE: 8 x 16 μm² (VxH FWHM)
- MAXIMISE FLUX AT SAMPLE: use all the beam
- 2 ENDSTATIONS
  - RIXS (Resonant Inelastic Xray Scattering)
  - XRS (Xray Raman Spectroscopy)

RIXS spectrometer: target energy resolution reached
UPBL4 – ID16
Nano-imaging & Nano-analysis
UPBL4 NINA on ID16

UPBL4 is a long, canted, high-β beamline with 2 branches:
- **NI**: ultimate pink beam focus for imaging and XRF
- **NA**: nanofocus monochromatic beam for spectroscopy

X-ray ultra-microscopy and nano-spectroscopy

<table>
<thead>
<tr>
<th></th>
<th>NI</th>
<th>NA</th>
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</thead>
<tbody>
<tr>
<td>Length</td>
<td>185 meters</td>
<td>165 meters</td>
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<tr>
<td>Spatial Res.</td>
<td>10 - 100 nm</td>
<td>50 nm -1 μm</td>
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<tr>
<td>DE/E (%)</td>
<td>1</td>
<td>0.01</td>
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<tr>
<td>Energy range</td>
<td>Discrete 11 – 17 – 33 keV</td>
<td>Scanning 5 →70 keV</td>
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<tr>
<td>Main goals</td>
<td>XRF, coherent XRI-2D/3D, Cryo environment</td>
<td>XAS, XRD, XRF, XRI-2D/3D in-situ experiments</td>
</tr>
<tr>
<td>Main fields</td>
<td>Biology &amp; Life Sciences, Nanotechnology &amp; Nanomedicine</td>
<td>Biology, environmental sciences, geoscience, materials sciences, ...</td>
</tr>
</tbody>
</table>
UPBL4 NINA on ID16

ID16A–NI
185 m

ID16B–NA
165 m

Optics Hutchen 34 m

UPBL4 Layout

Multilayer Optics

- 2.7 mrad
0 mrad
+ 2.7 mrad

Revolvers U18.3/U22.8
In-vacuum U26

NA-branch
Nano-Analysis

NI-branch
Nano-Imaging

- 18.7 mrad

UPBL4 NINA on ID16 Satellite Building

European Synchrotron Radiation Facility
UPBL7 – ID32

Soft X-rays: Nano-magnetism & Spectroscopy

- soft X-ray beamline (300 to 2500 eV) - 2 end stations (RIXS and XMCD)
- RIXS spectrometer designed for high energy resolution (25 meV - 900 eV)
The 12m RIXS spectrometer in EX2

EC1 in EH2
200 m²
Target combined resolving power $\sim 30000$ @ Cu L edge = $\sim 35\text{meV}$

RIXS spectrometer scattering arm
Continuous rotation over $\sim 100^\circ$
High resolution grating 2500 l/mm, total energy BW of the spectrometer vs. actual spatial resolution of the detector at 20deg incidence from CCD surface.
The best data at the SLS today are performed with $E/\Delta E = \sim 8000$.

"Ideal" spectrum at Cu L$_3$.

Energy loss (eV)

Courtesy of L. Braicovich (Milano)
All specifications have been reached.

Off-line commissioning on ID08

- UHV \((10^{-10}\text{mbar})\)
- SC magnet
- cold bore
- split coil
- 450-3K sample T
- 9T along beam \((8\text{T/min sweep rate})\)
- 4T perp. To beam \((2\text{T/min sweep rate})\)
UPBL10 – ID30
MASSIF (Structural Biology)
Infrastructure finished – progressive commissioning of new endstations

UPBL10:
ID30B – MAD – 1 station on long beamline
ID30A – 3 stations/high throughput
BM29 – BioSAXS

Village of MX stations
UPBL9a – ID02
Time-resolved ultra small angle scattering
32 m long vacuum tube with 2 m diameter
In-vacuum detector wagon with a selection of 3 2D-detectors
UPBL1 – ID01
Diffraction imaging for nano-analysis
Primary Optics

- Si (111) Bragg monochromators
  - double crystal geometry
  - channel cut geometry
- double multilayer monochromator
- white beam mirrors
- high power absorbers
SAXS tube existing on ID01,

SAXS/ GISAXS/ GID/ \(\mu\)-diff stage,

Nano-diffractometer, CDI, Diffraction, Grazing incidence with high precision sample positioning
New floor space – to be filled within the Upgrade Programme Phase II

Existing satellites:
ID11
ID13
ID16
ID17
ID19

Hall extension (EX2):
ID27 – ID02

New Hall extension:
ID06 – ID10

New long beamlines:
ID27 – ID29 (existing)