PHANGS workshop, Elettra, Trieste, Italy, 4-5 December 2017

The Photon Sources for The ESRF-EBS

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European Synchrotron Radiation Facility

ESRF | The European Synchrotron
ESRF-EBS

Insertion Devices in EBS context

- Migration & adaptation
- Minimum ID gap
- IDs schemes

Bending Magnet beamlines

Summary

* EBS: Extremely Brilliant Source
EBS: BRILLIANCE

**Present lattice (dashed)**

**New lattice (plain)**

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### ESRF Lattice

<table>
<thead>
<tr>
<th></th>
<th>Present</th>
<th>EBS</th>
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<tbody>
<tr>
<td>Hor. Emittance [nm]</td>
<td>4</td>
<td>0.134*</td>
</tr>
<tr>
<td>Vert. Emittance [pm]</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Energy spread [%]</td>
<td>0.1</td>
<td>0.095</td>
</tr>
<tr>
<td>Beta_x / Beta_z [m]</td>
<td>37/3</td>
<td>6.8/2.9</td>
</tr>
<tr>
<td>Beam current [mA]</td>
<td>200</td>
<td>200</td>
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</table>

* w/o IDs
Coherence fraction (expressed in $\lambda/2\pi$)
IDM* group task, except IDs

- Magnet design
- Procurement (about 1000 magnets)
- Measurements and fiducialization

*IDM: Insertion Devices and Magnets
PM DIPOLES: FROM CONCEPT TO IN-HOUSE SERIAL PRODUCTION

Longitudinal field steps

Design view

Assembly, measurement and alignment

In a few words…
132 dipoles, 1.8 m each
6 tons of Sm$_2$Co$_{17}$
Completed in October 2017
# EBS MASTER PLAN (2015-2020)

## Master Plan and Major Milestones

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<tbody>
<tr>
<td>Design, Procurement</td>
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<td>Assembly</td>
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<td>Beamline Commissioning</td>
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<tr>
<td>Friendly Users</td>
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Situation at the restart (2020)

- Same energy: 6 GeV
- Most of the existing ID to be reused in the EBS
- About 90 magnetic assemblies installed
  - 33 standard in-air undulators
  - 18 revolver undulators
  - 13 IVUs and CPMUs
  - 8 other devices
- Length of the straight sections: 5 m
  - Same length for most of sections
  - Length reduced 6 m → 5 m on a few sections
- Adaptation work on IVUs and CPMUs
IVU AND CPMU COMPATIBILITY ISSUES

IVU adaptation

- Integration of photon absorbers on both sides
- Modification of water cooling circuit (IVUs) & flexible transitions
- New conical chambers at both ends
- Implementation before September 2019
NEW UNDULATOR SUPPORTS

2.3 m undulator

2.3 m revolver undulator

Can be used for any refurbishment and upgrade of ID straights after EBS initial operation
Two devices / ID straight, can be combined with an IVU/CPMU
Adaptation of the canting sections

- PM canting magnets installed since 2012
- Entry and exit angles to be provided by the main dipoles
- Nearest dipole strength reduced by 2 to 2.7 mrad
- Middle canting magnet: same as present

Beam position at beamline location

- Same as present
- Max displacement: 0.2 mm
ID MINIMUM GAPS

Top-up operation for the EBS

• Smaller beam lifetime (Touschek)
• Increased beam losses at small apertures (IVUs/CPMUs)

Beam losses must be localized on collimators

• Important studies with present SR (top-up, 16 bunch)
• Validation of the beam losses model

Two collimators to be installed on the EBS

• Important studies with present SR (top-up, 16 bunch)
• Cell 13 & 24
• 30 cm long tungsten blades
• Variable horizontal position
• Important shielding around collimators
Scraper studies

- 80% of the losses relocated on the scrapers
- 4% lifetime reduction
CPMUs in operation

<table>
<thead>
<tr>
<th>ID straight</th>
<th>Period [mm]</th>
<th>Length [m]</th>
<th>Gap [mm]</th>
<th>Peak Field [T]</th>
<th>PM</th>
<th>Instal. date</th>
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<tbody>
<tr>
<td>6</td>
<td>18</td>
<td>2</td>
<td>6</td>
<td>0.88</td>
<td>NdFeB</td>
<td>Jan. 2008</td>
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<tr>
<td>11</td>
<td>18</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>NdFeB</td>
<td>Jan. 2012</td>
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<tr>
<td>31</td>
<td>14.4</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>PrFeB</td>
<td>Jul. 2016</td>
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</table>

Plans

- Large demand from beamlines
- One lab fully dedicated to CPMU/IVU construction (2020)
Design view of the *in situ* Hall probe bench
(stretched wire system not shown)

(Design in collaboration with ProActive Engineering, Spain)
Laser setup for the measurement of the transverse positions and roll angle of the Hall probe.
MAGNETIC MEASUREMENTS: CPMU14

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Gap scan around harmonic 7 (100.75 keV)  
(Courtesy V. Honkinaki)
Energy scan from beamline 63 keV-130 keV
Undulator gap 5.4 mm

( V. Honkinaki)

Computed Energy scan 63-130 keV
Undulator gap 5.35 mm
Ideal undulator with measured peak field
0.04 mm gap tapering
Aperture: 300µm x 300µm @ 30 m
Magnet holders

- Based on the last CPMU (14.5 mm period)
- Efficient phase error correction
- Fine tuning of individual poles

Standard design

- Now fully parameterized
- 10 mm to 21 mm period
- Adaptable to any length
- End field structure included
LN2 COOLING INFRASTRUCTURE IN EBS

LN2 cooling loop

- To be implemented in the technical gallery
- For future CPMU installation
- LN2 outlet in each cell
- Available at restart of EBS
- Cell 32, 1 and 2 need further studies
# ID CONSTRUCTION FROM 2020

<table>
<thead>
<tr>
<th>CDR #</th>
<th>Application</th>
<th>BL</th>
<th>Source</th>
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<tbody>
<tr>
<td>1</td>
<td>Coherence applications</td>
<td>ID10</td>
<td>2 x CPMU18</td>
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<tr>
<td>2</td>
<td>Hard X-ray diffraction microscopy</td>
<td>ID08</td>
<td>CPMU14, CPMU18</td>
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<tr>
<td>3</td>
<td>Large phase-contrast tomography</td>
<td>BM18</td>
<td>3 pole wiggler</td>
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<tr>
<td>4</td>
<td>Surface science</td>
<td>ID03</td>
<td>U27/U35</td>
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<tr>
<td>5</td>
<td>Extreme conditions</td>
<td>ID27</td>
<td>2 x CPMU18</td>
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<tr>
<td>6</td>
<td>Dynamic compression studies</td>
<td>ID23-ID24</td>
<td>CPMU18, CPMU12</td>
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</table>
BENDING MAGNET SOURCES: CONTEXT

ESRF EBS
7BA  6 GeV lattice

BM sources
Combined low field dipole-quads (DQ)
⇒ 0.39 T DQ, $E_{\downarrow C} = 9.3$ keV
⇒ 0.57 T DQ, $E_{\downarrow C} = 13.6$ keV
⇒ 2 mrad max

Present ESRF
DBA  6 GeV lattice
Very productive BM beamlines

BM sources
⇒ 0.856 T bending magnet, $E_{\downarrow C} = 20.5$ keV
⇒ 0.4 T soft end, $E_{\downarrow C} = 9.5$ keV
⇒ 6 mrad max
BM X-Ray fans limited to 4 mrad due to limitations imposed on photon beam path in magnets
INCOMING BEAM(S) AT BEAMLINE (DQ2C & DQ1D ONLY)

Storage ring tunnel

2 separated beams

Experimental hall

Photon flux [a.u]

E=10 keV

E=50 keV

Horizontal angle [mrad]

Vertical angle [mrad]

Photon flux [a.u]
PROPOSED ALTERNATIVE SOURCES

Options available

*Short Bending Magnet (SBM)*
- 2 mrad X-ray fan
- 7 SBM to be installed

*2-poles wiggler (2PW)*
- 1.7 mrad fan
- 2 configurations
- 6 2PW to be installed

*3-pole wiggler*
- 1.6 mrad fan
- 2 3PW to be installed

*Peak field: 0.86 T for all sources*

*White beam at 25 m*
ESRF EBS
Procurement in progress, assembly started

Insertion devices
• Initial operation with present ID segments
• Operational experience very positive with CPMUs
• Large demand for CPMUs/IVUs to anticipate
• Dedicated lab for construction of CPMUs

Bending Magnet beamlines
• New sources: SBM, 2PWs, 3PWs