SWISS LIGHT SOURCE

MS Upgrade Newsletter

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Building for a brighter future!

Welcome from the MS beamline! The Materials Science beamline was one of the first four to be built at the SLS and first saw light in 2001. The beamline was unique in being served by a 61-mm-period wiggler source (W61), which allowed access to photon energies as high as 40 keV [1]. Since its inception, the MS beamline has provided high-quality synchrotron radiation for both powder diffraction and surface diffraction experiments. Recent scientific highlights are shown in Fig. 1.

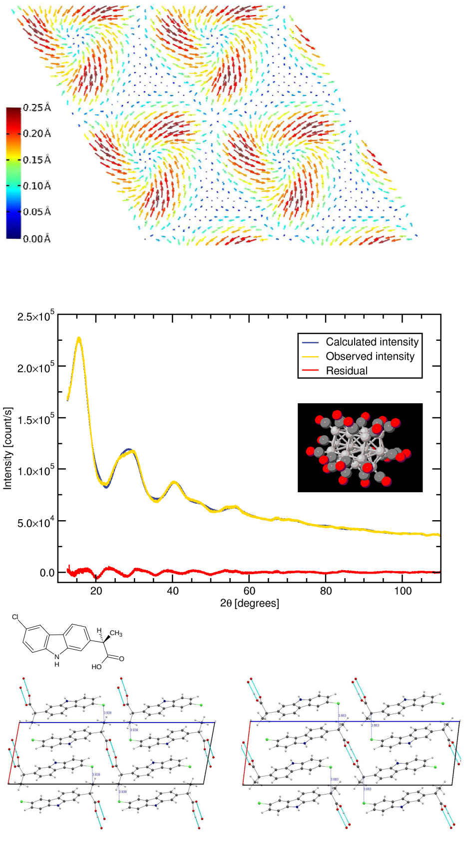


Figure 1: Highlights from the Materials Science beamline. Top: SXRD revealed that the single-layer graphene deposited epitaxially on Ru(0001) forms a regular corrugation of hilllike structures, which exhibit chiral rotation on their flanks [2]. Middle: diffraction pattern of Pt 19 (CO)22 nanosuspensions [3]. Bottom: Temperature-induced isostructural transformation in the non-steroidal anti-inflammatory drug carprofen with high-resolution, dose controlled, x-ray powder diffraction using MYTHEN II [4].

In the meantime, undulator and storage ring technologies have made significant steps, especially with regards to magnetic materials and control of the electron beam. It is now possible to obtain similar fluxes to that provided by the W61 and a much improved brilliance using an undulator.

It was therefore decided in 2008 that the MS beamline would undergo a comprehensive upgrade. The wiggler is to be replaced by a short-period (14 mm) in-vacuum, cryogenically cooled, permanent-magnet undulator, (CPMU, U14), while the front end and optics have been completely redesigned to optimally exploit the characteristics of the U14 source. In addition to providing fundamental improvements to both powder and SXRD experiments, the upgrade should allow new experimental setups previously excluded to the beamline.

Source comparison

The flux spectra of the U14 in comparison to the W61 is shown in Fig. 2.

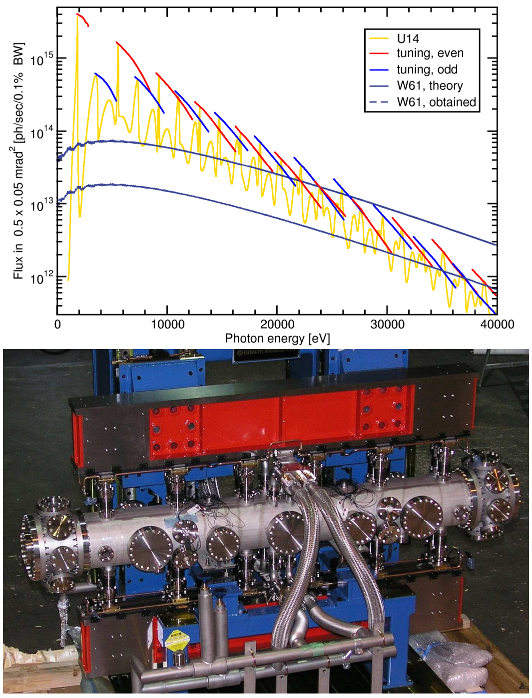


Figure 2: Top: Comparison of the flux into 0.5 x 0.05 mrad^2 of the U14 undulator and the W61 wiggler. Bottom: The U14 as delivered.

Below are the most important U14 parameters:

Parameter	Value
Undulator period	14 mm
Number of periods	120
Magnetic field strength	1.15 T @ 4 mm
K_{eff}	1.2 - 1.7
β_{x0}	1.38 m
β_{z0}	1.0 m
Emittance ε_x	5.1 nm rad
Coupling κ	0.002

Optics

Because of the much higher brilliance and over 100 times smaller beam size, the optics for the beamline will be completely replaced. The main components of the optics will consist of a double-crystal monochromator (DCM, Cinel) followed by two mirrors (flat + vertical focus, PSI in-house) shown in Fig. 3. The second crystal in the DCM can horizontally focus using a sagittal bender [5].

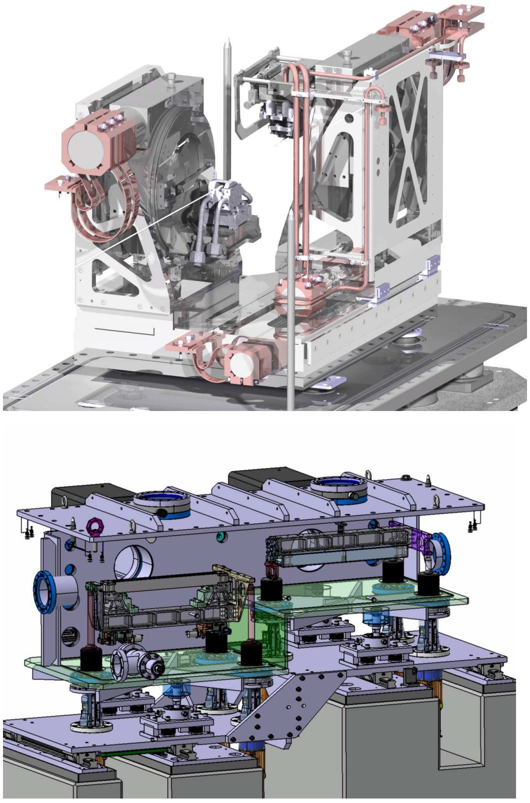


Figure 3: Top: The heart of the new DCM designed by Cinel, Padova, showing the two goniometer stages. Bottom: The two-mirror chamber, designed in house.

The mirrors are made of silicon and have three stripes: bare silicon, rhodium, and platinum. The minimum bend radius of mirror 2 will allow a 1:2 demagnification at the powder station, which is planned to be moved upstream for this purpose.

For experiments exploiting the coherent core of the beam (coherent diffractive imaging, CDI), only the second, bendable, mirror will be used, in order to minimize the number of optical elements and hence also distortion of the wavefront. Pink beam for Laue experiments will become available, whereby the beam can be tilted either up or down (for liquids). A schematic of the four modes is shown in Fig. 4.

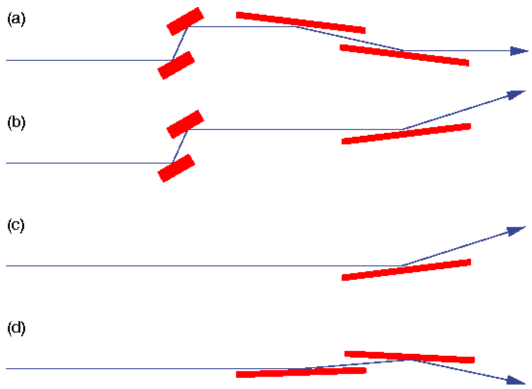
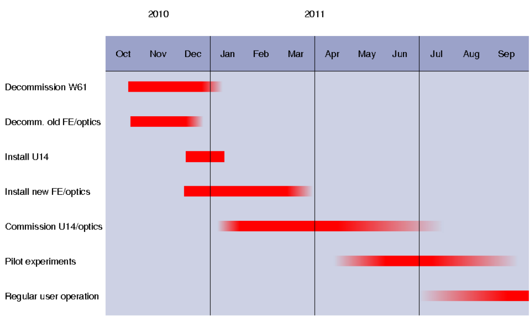


Figure 4: Available modes at the 4S beamline using the new optics: (a) monochromatic, fixed exit height; (b) monochromatic, one mirror only (for CDI experiments); (c) pink beam, tilted up; (d) pink beam, tilted down.

Time schedule

Below is the expected time schedule at the time of writing.



Regular user operation will recommence as early as is feasible in the second half of 2011. Prior to this, a two-month period will be reserved for expert pilot experiments. A more precise time schedule should be possible in the next newsletter.

New techniques

In addition to the expected increase in performance of the two established techniques at the MS beamline (powder and surface diffraction), it is envisaged that the following techniques will be developed:

1) microbeam Laue diffraction using the relatively large background spectra of the high-K undulator (Fig. 2).

2) coherent diffraction imaging (CDI). This is particularly interesting for the MS beamline, as speckle around Bragg peaks far from the direct beam can be accessed using the surface diffractometer.

3) SAXS/WAXS. These techniques are expected to become invaluable adjuncts that can be used in parallel with more conventional powder and single crystal diffraction experiments.

All the above techniques will use EIGER detectors, the next generation hybrid pixel detectors developed at the PSI.

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References

1. B.D. Patterson *et al*., *Nucl. Instrum. Methods A* **540**, 42 (2005).
2. D. Martoccia *et al*., *New J. Phys* **12**, 043028 (2010).
3. A.. Cervellino, unpublished results.
4. F. Gozzo, unpublished results.
5. C. Schulze-Briese *et al*., *Proc. SPIE***, 3448**, 156 (1998).