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The mySpot beamline at BESSY II

Helmholtz-Zentrum Berlin für Materialien und Energie *

Instrument Scientist:
- Dr. Ivo Zizak, Helmholtz-Zentrum Berlin für Materialien und Energie, phone: +49 30 8062- 12127, email: zizak@helmholtz-berlin.de

Abstract: mySpot beamline is used to provide stable beam especially tuned for the mySpot experiment. Depending on the experiment requirements, different optical devices are used. The schematic view shows two different configurations, one tuned for low divergence, and one for narrow energy band width, as required for the scattering and spectroscopy experiments respectively. Since the goal of the experiment is to provide several methods at the same time, beamline properties can be tuned to provide the optimal beam for a given combination of experiments. Total intensity, divergence, energy resolution, high harmonics suppression, and stability in scans can be tuned to match the requirements (Erko & Zizak, 2009).

1 Introduction

The mySpot beamline is mounted on the 7 T wavelength shifter at the BESSY II synchrotron radiation ring. The toroidal total external reflection mirror is placed in the front end, before the main beam shutter. Such a location of the mirror provides large photon flux, improoving acceptance of the beamline in horizontal and vertical directions (Erko et al., 2004). In the monochromator of mySpot beamline two pairs of crystal-monochromators are used: Si (111), $\lambda/\Delta\lambda$ ~5,000 and Si (311), $\lambda/\Delta\lambda$ ~10,000 as well as double-multilayers mirror with Mo/B_4C coating, $\lambda/\Delta\lambda$ ~30. Multilayer period is equal to 2 nm. In comparison with crystals, multilayer mirrors providing approximately 50 times higher photon flux on a sample due to the lower energy resolution. This versatile monochromator allows for different experiments to be performed, choosing the photon flux and energy band width as needed for experiment: Multilayer for fluorescence analysis and diffuse scattering, Si (111) for diffraction and EXAFS, and Si (311) for high-resolution XANES experiments.
The toroidal mirror can be used for vertical collimation the beam or for direct focusing to the sample position. Horizontal focus is always at the sample position, and if no slits are used it is 400 μm large. Two setups are schematically shown in Figure 2. Selection of the option depends on experiment

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requirements, in a similar way as the selection of the monochromator. For low divergence needed in small angle scattering experiments, the beam is directly focused without using the second mirror. For high energy resolution it is necessary that the parallel beam passes the monochromator, and in this case the second, focusing, mirror is used to focus the beam at the sample position. The focusing mirror is an 8-segment bimorph cylindrical mirror. If only one mirror is used, the vertical focus size is about 300 μm large. By fine-tuning the bending radius of the 8 segments in the second mirror it is possible to correct for the surface errors of the first mirror and achieve the focus with the vertical size of only 30 μm, increasing the flux at the sample one order of magnitude. However, since the focusing mirror is too close to the sample the beam divergence is mostly too large for diffraction and small angle scattering experiments.

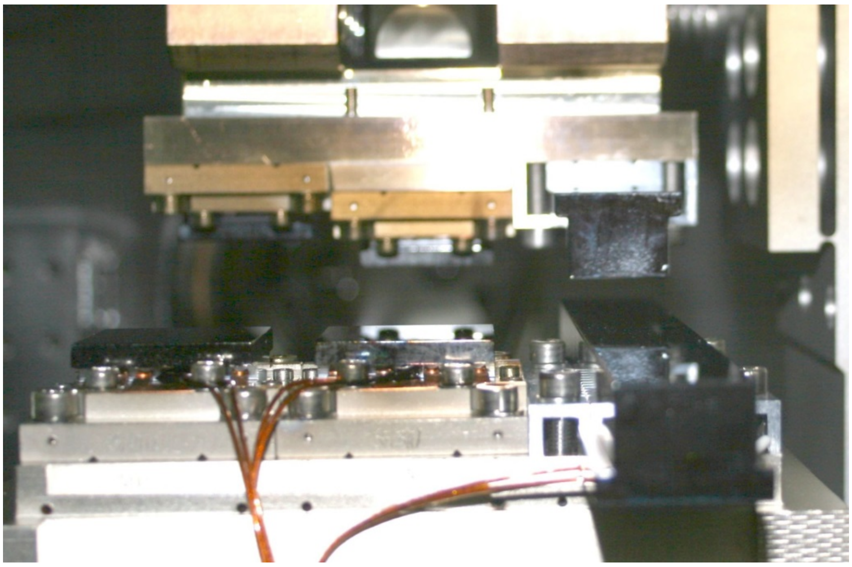

Figure 1: 3 monochromators of the mySpot Beamline, left to right: Si (111), Si (311), Mo/B_4C Multilayer.

2 Instrument application

The main purpose of the mySpot beamline is to provide photons for the mySpot experiment. All the beamline parameters can be tuned from the experiment.

Low divergence application: The second mirror is not used. The beam is focused hirisontally and vertically directly to the sample position. Beam size is 400 x 400 μm^2. This creates additional energy band broadening, and cannot be combined with XANES experiment.

Narrow energy bandwidth: First mirror is used to parallelize the beam, so there is no additional broadening in the monochromator. Second mirror is focusing the beam at the sample position. Beam size at the sample position is 400 x 50 μmm^2. Additionally, a Si (311) crystal pair is used for narrow energy bandwidth. Unfortunately, this influences the total intensity.

High flux option: A multilayer monochromator is used when there is no requirement on the energy bandwidth, like in diffuse scattering and fluorescence mapping.

The second mirror has three different coatings, which can be used to suppress the higher harmonics to ensure the beam purity for different energy ranges.

To provide the extreme stability during the energy scans, the monochromator is operated in a servo loop using the feedback from the beam intensity monitor at the end of the beamline.

For microfocussing experiments with the beam size down to 1 μm^2, the beam is additionally refocused very close to the sample using single bounce or capillary optics. Small distance between the sample and focusing optics provides for the extreme vibration and position stability during the scans, ao that micro-EXAFS and micro-XANES experiment are possible. See the experiment page for more details.

3 Source

The insertion device is the superconducting 7 T wavelength shifter 7T-WLS-2 with the following parameters

Type	Supercoducting WLS
Location	
Periods/Pols	3 n

Table 1: Parameters of 7T-WLS-2.

4 Optical Design

Highly modular optics allows for two different types of beam focusing, and three different energy bandwidths. Energy bandwidth is selected by choosing one of three monochromators: Multilayer for high flux, Si(111) for moderate flux and energy resolution, and Si(311) for narrow energy bandwidth as required for XANES experiments. Two different choices of focusing allow to select between low divergence and small focal spot. Minimal focal spot is 400 x 100 μm, but can be further reduced using capillary optics. Refocussing the beam using capillary optics allows for the polydisperse focusing, and can be used even in Spectroscopy measurements where the focal spot is not depending of the energy of the focused radiation.

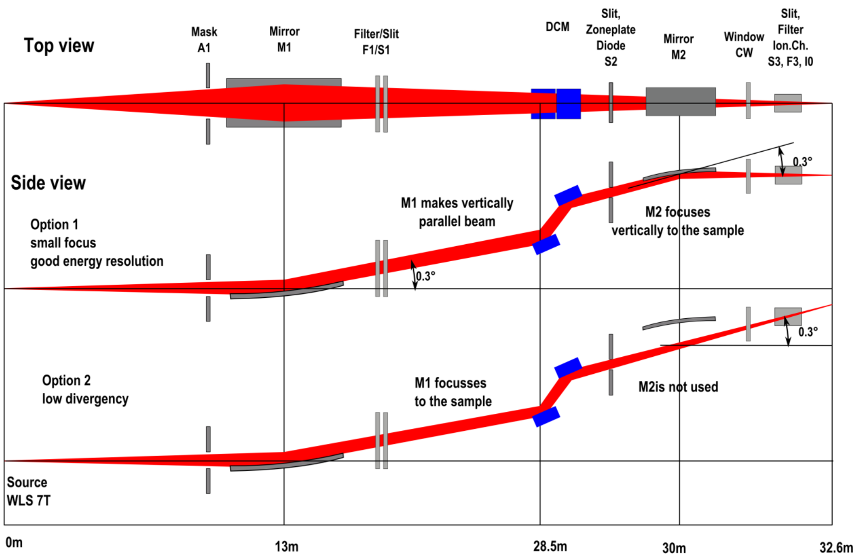

Figure 2: Optical layout of beamline mySpot.

5 Technical Data

Location	3.2
Source	7T-WLS-1
Monochromator	Si(111) and Si(111) crystal monochromator/ Mo/B_4C Multilayer
Energy range	4 – 30 keV (not all energies are available for all experiments)
Energy resolution	λE/E depending on monochomator: from 1/500 to 1/8000
Flux	10^{12} – 10^{13} ph/s, depending on monochromator and optics
Polarization	horizontal
Divergence horizontal	1 mrad
Divergence vertica	1 mrad
Focus size (hor. x vert.)	400 x 400, 400 x 50, further focusing in experimental hutch
Distance Focus/last valve	Variable mm
Height Focus/floorlevel	1500 mm
Free photon beam available	No, beamline dedicated to mySpot experiment
Fixed endstation	Yes, mySpot

Table 2: Technical parameters of mySpot beamline.

References

Erko, A., Schäfers, F., Firsov, A., Peatman, W., Eberhardt, W., & Signorato, R. (2004). The BESSY X-ray microfocus beamline project. *Spectrochimica Acta Part B: Atomic Spectroscopy*, *59*(10–11), 1543 - 1548. (17th International Congress on X-Ray Optics and Microanalysis) http://dx.doi.org/10.1016/j.sab.2004.03.015

Erko, A., & Zizak, I. (2009). Hard X-ray micro-spectroscopy at Berliner Elektronenspeicherring für Synchrotronstrahlung II. *Spectrochimica Acta Part B: Atomic Spectroscopy*, *64*(9), 833 - 848. http://dx.doi.org/10.1016/j.sab.2009.07.003