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# UE112_PGM-1: An open-port low-energy beamline at the BESSY II undulator UE112

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**Abstract:** The X-ray optical and mechanical designs of a low-energy high-flux VUV- to soft-X-ray beamline for photon energies between 17 and 200 eV (with lower flux up to 690 eV) are presented.

## 1 Introduction

The UE112_PGM-1 installation is a low-energy high-flux X-ray beamline with variable (linear and elliptical) polarization. It is a combination of the UE112, a modern APPLE-II-type undulator, coupled to a collimated plane-grating monochromator (Follath et al., 1997, 1998, 2001). It features high resolving power, high throughput and small spot size at the experiment for X-ray energies between 17 eV and 690 eV. The X-ray beam is focused into a small spot with a diameter of about 80 µm, without a significant halo. The focal distance from the last beamline valve is about 1 m and the available target area on the floor is large enough to enable the installation of relatively large experimental setups. Thus, the beamline includes no fixed end station and it is optimized for variable modes of operation using very different experimental chambers (typically these are end stations).

## 2 Source

The insertion device is an APPLE-II-type elliptical undulator with the following parameters:

| | |
|---|---|
| Location | H13 |
| Source | undulator UE112 |
| Polarization | linear horizontal, linear vertical, elliptical, and circular |
| Period | 112.0 mm |
| Number of Periods | 32 |
| Minimum Energy | 4.93 eV |

Table 1: Information summary on the insertion device

## 3 Optical Design

The optical layout of the beamline (all values in the subsequent schema are design parameters, dimensions given in mm) (Follath et al., 1997, 1998, 2001) is described in the following. M1 is a toroidal mirror which collimates the light in the horizontal and vertical directions. The plane mirror M2 is used to vary the deviation angle at the plane grating G. Vertically, the diffracted light is focused onto the (horizontal) exit slit S by the cylindrical mirror M3. Al (150 nm thick) and Mg foils (240 nm thick) allow for a suppression of higher order X-rays at E > 73 eV (Al) or E > 50 eV (Mg). The subsequent refocusing is performed by the mirrors M4 and M5 in the vertical and horizontal directions, respectively. Actual measured values of the focus position are given in the instrument-data table further below.

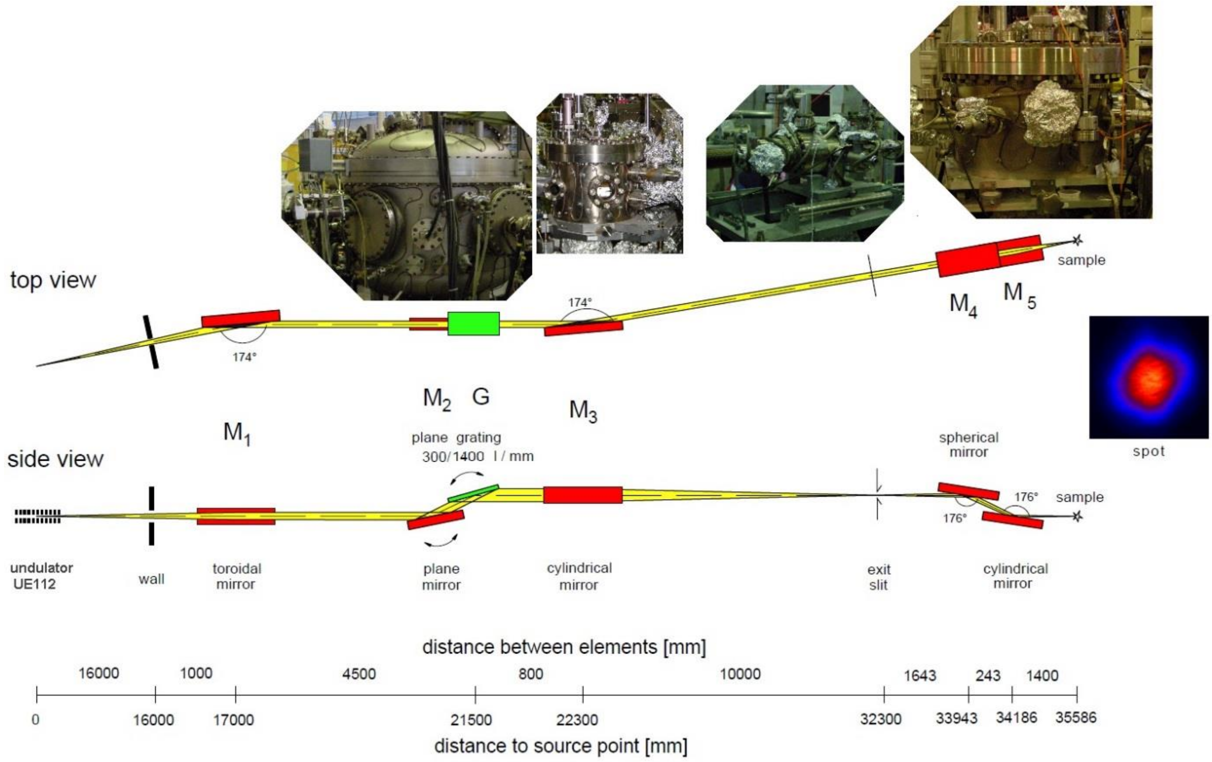


Figure 1: The optical layout of beamline UE112_PGM-1.

## 4 All-over Performance Data

Performance data related to the focal point are given in the following (Follath et al., 1997, 1998, 2001; Savci & Schiwietz, 2013):

| | |
|---|---|
| Location | 14.2 |
| Energy range | 17 – 690 eV |
| Energy resolution * | 30,000 (17-150eV)<br>> 20,000 (150-350eV) |
| Flux * | > $10^{12}$ ph/s (20-280eV)<br>> 2 x $10^{13}$ ph/s (50-150eV) |
| Polarization | variable |
| Divergence horizontal | 1.4 @ 63.5eV mrad |
| Divergence vertical | 0.6 @ 63.5eV mrad |
| Focus size (hor. x vert.) | optimum: ca. 0.08 x 0.08 mm |
| Distance: Focus-last valve | ca. 1068 mm |
| Height: Focus-floor level | ca. 1396.5 mm (1393 mm at the exit of the refocusing chamber) |
| Fixed end station | no |

* parameters given for standard grating[1]

Table 2: Instrument-data table: technical summary on the undulator/monochromator combination.

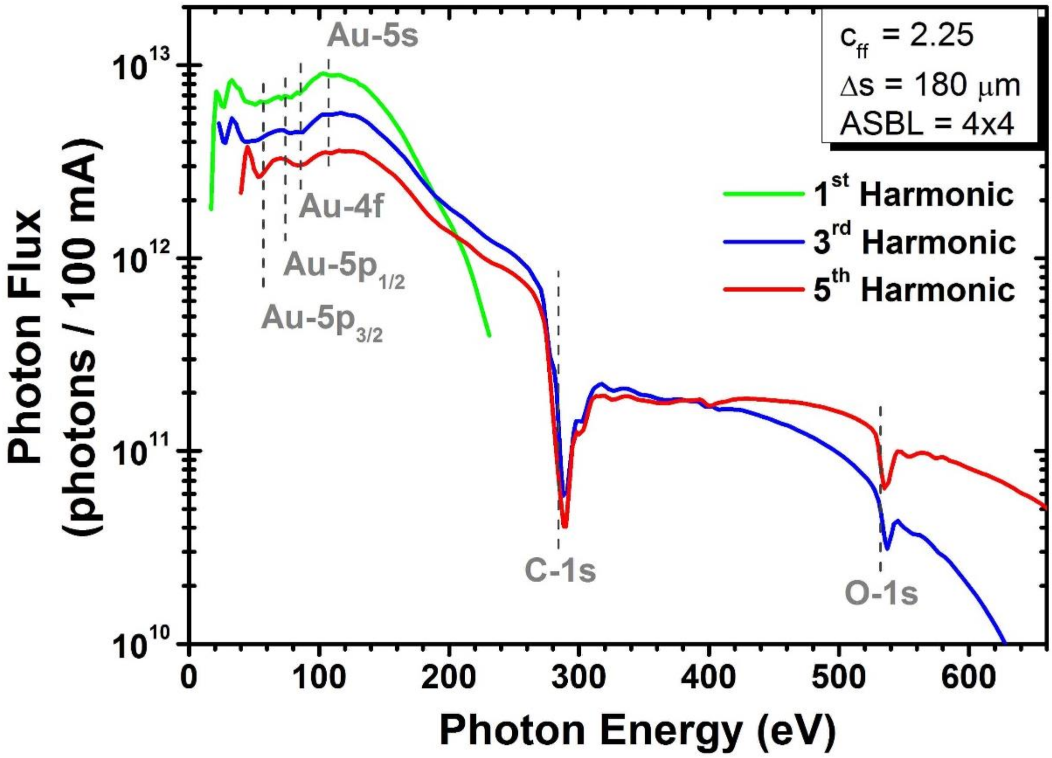


Figure 2: Normalized photon flux (wrt. the synchrotron-ring current) at the exit of the beamline UE112_PGM-1 for standard conditions and three different undulator harmonics.[1] Typically BESSY II runs with a ring current of 300 mA

[1] Savci A. & Schiwietz G. (2013). Actual measurements of beamline parameters have been performed in the years 2013 and 2014.

## 5 User Chambers

Some selected examples for user chambers attached to UE112_PGM-1:

- PHOENEXS – a (Spin Resolved) Photoemission and Near Edge X-ray Station, operated by HZB.
- ArTOF – various Angle-Resolved Time-of-Flight systems featuring high resolution and large detection solid-angle, operated by groups of Uppsala University and HZB.
- COLTRIMS – a system for Cold Target Recoil Ion Momentum Spectroscopy (COLTRIMS) for electron/ion coincidences in the gas phase, operated by groups of Goethe-Universität Frankfurt.
- ET – the electron timing chamber (Schiwietz et al, 2015) equipped with the retarding Bessel Box (RBB) electrostatic electron spectrometer, operated by HZB (Schiwietz et al., 2015).
- Liquid or solid FlexRIXS –end stations with soft X-ray emission spectrometers for RIXS (Resonant Inelastic X-ray Scattering) investigations of fluid and solid-state targets respectively, operated by HZB.

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