

# First tests of a prototype PETRA III high heat load monochromator at ID06 of the ESRF

*H.-C. Wille, C. Detlefs<sup>1</sup>, U. Hahn, J. Heuer, J. Horbach, R. Röhlberger, T. Roth<sup>1</sup>, D. Samberg, and H. Schulte-Schrepping*

<sup>1</sup>European Synchrotron Radiation Facility, BP 220, 38043 Grenoble, France

We report on the actual status of the monochromator tests at the beamline ID06 of ESRF. ID06 is partly dedicated to x-ray optics tests within the framework of the ESRF-DESY cooperation agreement. Although the beamline is still in its construction phase, the optics hutch (OH) became operational this year. The prototype high heat load monochromator (HHLM) for PETRA III produced by OXFORD DANFYSIK has been installed in the OH this summer. First beam in the optics hutch was taken on October 1<sup>st</sup> and the first monochromatic beam from the HHLM was detected on 14<sup>th</sup> of October 2007. The setup of the optics hutch of ID06 is shown in Fig. 1.

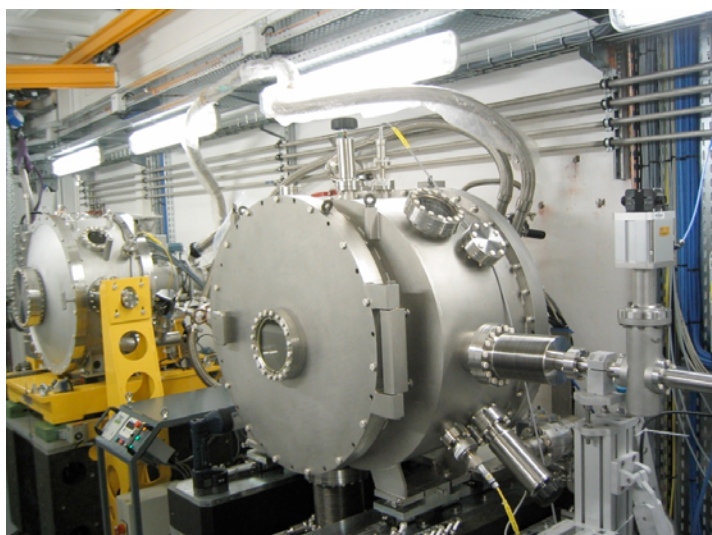
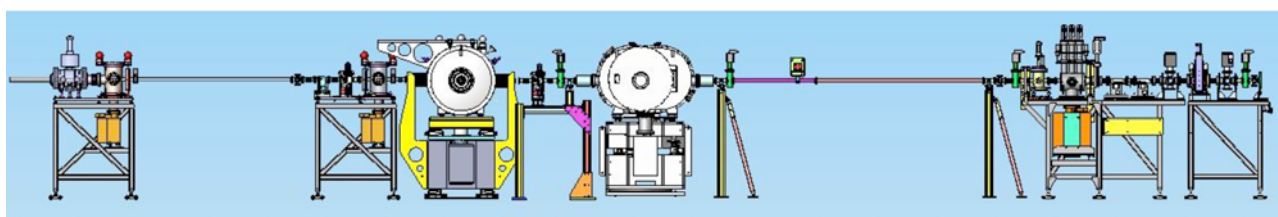


Figure 1: Top: Overview of the ID06 optics hutch. The beam enters the hutch from the right, where it passes the high-power slits and a filter/absorber stage for beam conditioning. After a few meters of transport, the beam reaches the PETRA III prototype monochromator. For the physics program at ID06, a second monochromator has been installed further downstream by ESRF. The slit 3 is located downstream the 2<sup>nd</sup> monochromator. Left: View into the ID6 hutch with the PETRA III prototype monochromator in the foreground and the ESRF monochromator further downstream.

First tests of the PETRA III HHLM were dedicated to its general functionality under beam conditions. To cope with the heat load impinging on the silicon crystals, the crystals are cryogenically cooled, following an ESRF design of the crystal support structure. Ideally, the temperature should be stabilized around 125 K where the lattice thermal expansion coefficient of silicon vanishes. As a first check the rocking curve width of the second crystal was measured at different photon energies and compared to theoretical values. Two examples are shown in the Figs. 2 and 3. The angular scans show the expected shape of the convolution of two reflection curves and their FWHM fits well to the theoretical value calculated using the dynamical theory of x-ray diffraction.

In order to test the energy tunability and to calibrate the Bragg axis in energy, different absorption edges were measured by scanning the Bragg axis. Two examples are shown below (Figs. 4,5).

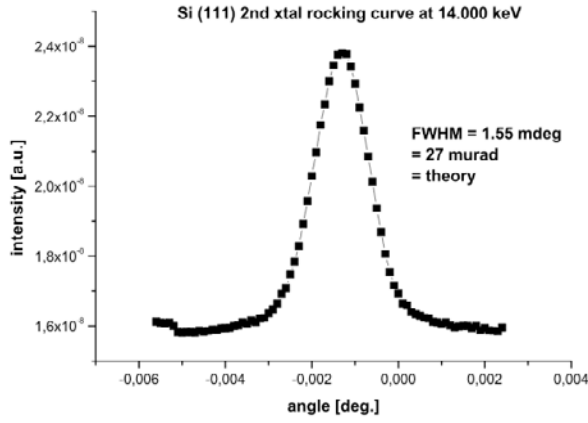


Figure 2: Si (111) rocking curve at 14.000 keV.

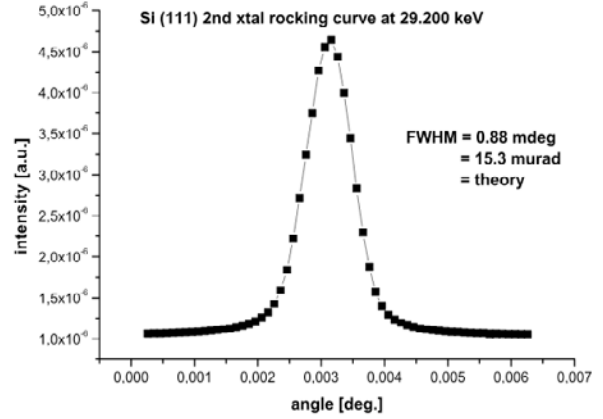


Figure 3: Si (111) rocking curve at 29.200 keV.

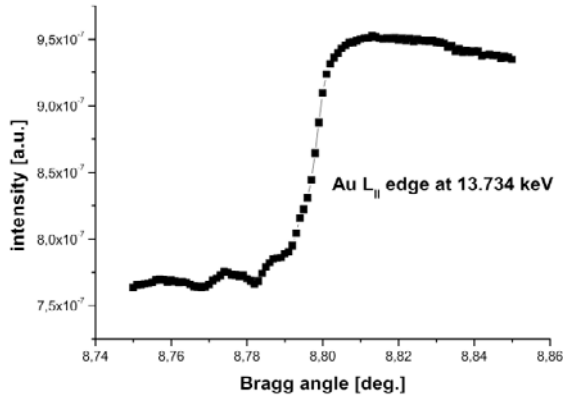


Figure 4: The Au LII edge.

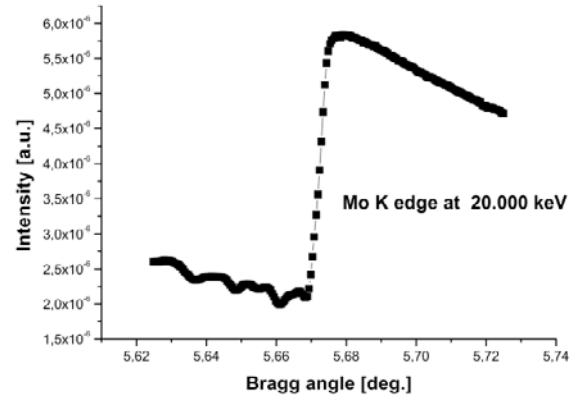


Figure. 5: The Mo K edge.

The edges and their fine structure are well resolved. Further tests were devoted to the long and short term angular stability. The latter is important for applications where a high directional stability of the beam (e.g. for nano focussing) and/or energy stability (e.g. high resolution/inelastic scattering) are required. Figures 6 and 7 show rocking curves of the 2<sup>nd</sup> crystal collected within 3.5 and 12 hrs respectively. A drift of about 1  $\mu$ rad per hour can be extracted. This is measured without any piezo fine tuning or feed back loop.

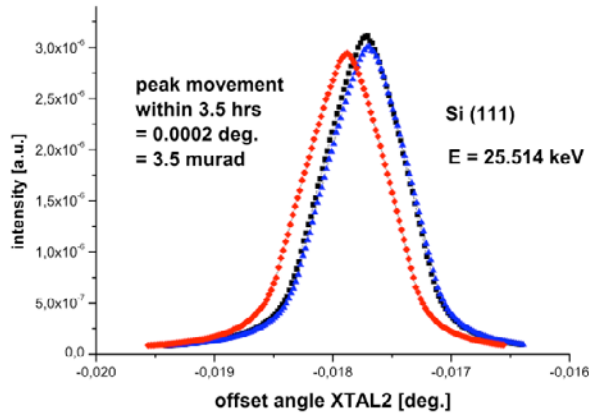


Figure 6: Peak movement within 3.5 hrs.

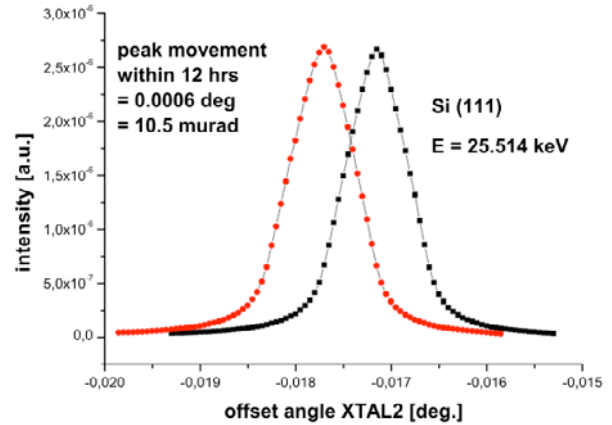


Figure 7: Peak movement within 12 hrs.

The long-term drift of the two crystals has been studied in two different ways. The encoder readout of the central rotation has been recorded over a long time as shown in Fig. 8 (both crystals are rotated together around this axis.)

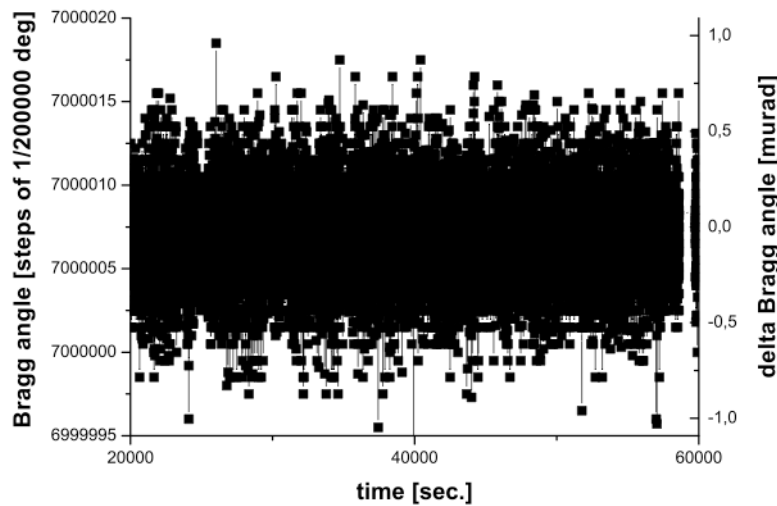


Figure 8: Time scan on the Bragg axis encoder (1 data point every 2 seconds) over a time of 11 hours.

The second test was done by partly blocking the monochromatic beam behind the HHLM with the lower blade of slit3, which is located 3610 mm away from the 2<sup>nd</sup> crystal and then monitoring the intensity over time. Figure 9 shows a height scan of the slit blade and the resulting angular dependence of the intensity. Figure 10 shows a time scan of the intensity and the resulting angular drift measured at a slit blade position of 1.1 mm, corresponding to the inflection point of the curve in Fig. 9.

It can be stated that the measured values for the long-term angular stability at this stage are still above the specified limits. Further studies will be devoted to the origin of the angular motions and actions will be taken to further reduce these drifts, e.g., by stiffening mechanical joints, adding thermal protection and/or reducing the degrees of motional freedom. The origin of these fluctuations has to be correlated with the stability of the mechanics and the position of the incoming white beam.

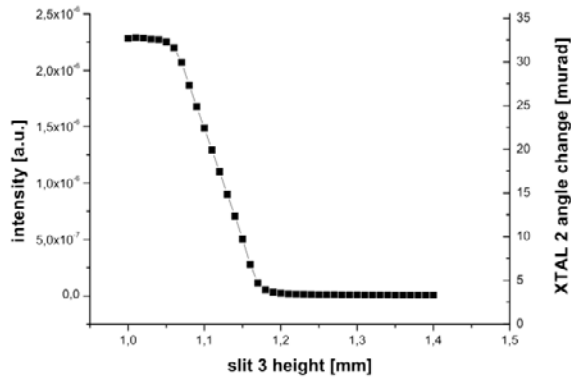


Figure 9: Height scan of the lower blade of slit3.

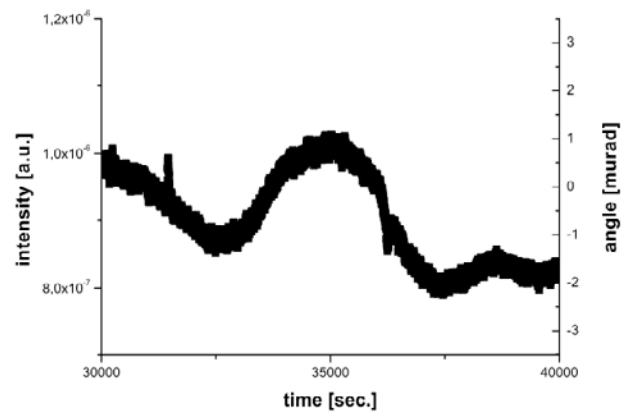


Figure 10: Intensity time scan and resulting angular drift.

The short term or high frequency stability of the crystals has been measured using a laser vibrometer of type Polytec OFV-505. Vibrations of the first and second crystal case have been recorded as function of pump frequency. Vibrational spectra (vibrational amplitude as function of vibrational frequency) for two selected frequencies of the cryopump are shown in Fig. 11. One observes discrete lines at vibrational frequencies above 100 Hz. The origin of these lines lies most probably in the periodic structure of the flexible hoses through which the liquid nitrogen is pumped. The amplitude of these vibrations is strongly dependent on the operating frequency of the cryogenic pump. The investigations have shown that one can find pumping frequencies where these vibrations are very small. A systematic investigation of the angular vibrations of the two crystals still has to be performed.

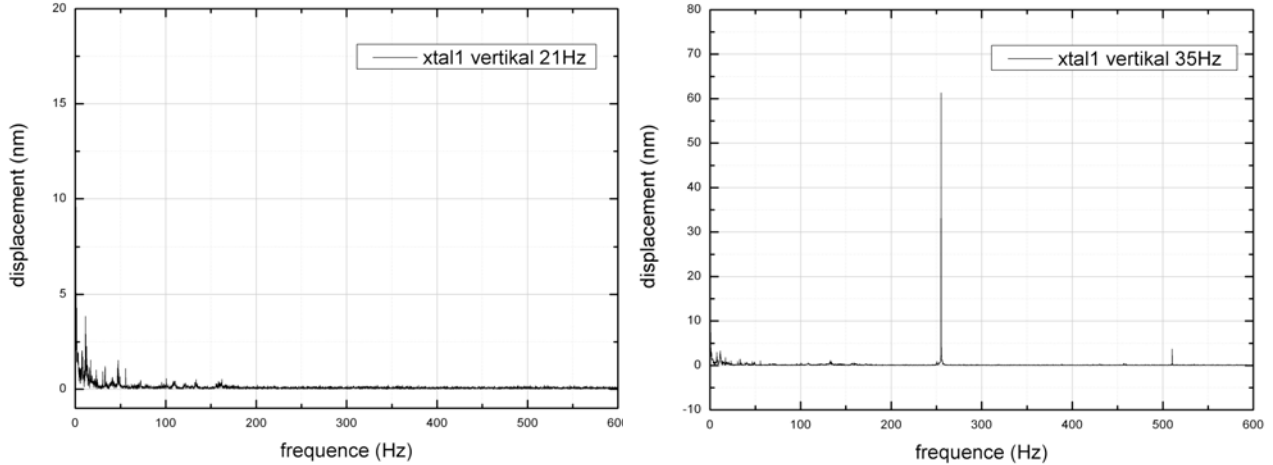


Figure 11: Vibrational spectra of the first monochromator crystal measured with the Polytec OFV 505 vibrometer for two frequencies of the cryogenic pump: 21 Hz (left) and 35 Hz (right). The vibrational amplitude detected here is parallel to the surface normal of the crystal. A striking feature at 35 Hz is the appearance of a discrete vibrational line at a frequency of about 250 Hz, which is most likely related to vibrations excited by the flowing nitrogen at the interior of the flexible hoses. These investigations have shown that the spectrum of vibrational excitations very sensitively depends on the frequency of the cryogenic pump. In most cases sufficiently ‘quiet’ operating conditions could be found.