A beamline for bulk sample X-ray absorption spectroscopy at the high brilliance storage ring PETRA III

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New and upgraded storage rings aim at ever higher brilliance which together with the increased coherence of the photon beam enables many novel and unique experiments. At the same time widespread used methods like X-ray absorption fine structure spectroscopy (XAFS), which is used as an important analytical method in many fields of applied science like catalysis and energy storage research, material sciences and environmental and geochemical applications, often do not benefit from the high source brilliance. They require a mm^2 sized beam, a stable beam position during X-ray photon energy scans over typical scan ranges of 1 – 2 keV and a moderately high monochromatic photon flux of 10^9 – 10^{12} s^{-1}. A typical example are in-situ samples in gas flow cells, which must have diameters in the mm range to allow realistic gas flow and pressure conditions. Due to their influence on the electron beam emittance and simple geometric restrictions the use of bending magnets or wigglers as sources for these methods is often not possible.

Recently, DESY has built two new, complementary XAFS beamlines at PETRA III . Beamline P65 was designed with the goal to provide a mm-sized beam, optimised for routine applied XAFS applications which require a robust and user friendly set-up comparable to typical bending magnet beamlines but with significantly increased flux which enables faster experiments and continuous scans. The beamline commissioning started in November 2015 and since June 2016 the beamline is in routine user operation.

The design of the beamline is based on a water cooled double crystal monochromator (Si 111 and Si 311) and a short (11 periods) undulator. The distance between DCM and sample is < 6 m to minimise the effect of unavoidable vibrations during the continuous energy scans. Two plane mirrors in front of the DCM act as low pass filters and decrease the power load on the first DCM crystal. Key parameter are a working range of 4 keV – 44 keV, a monochromatic photon flux of up to $10^{12} s^{-1}$(Si 111 @ 9keV), and an energy resolution of $1.4 * 10^{-4}$ (Si 111) and $0.6 * 10^{-4}$ (Si 311). The undulator gap is scanned synchronised with the scan of the DCM. The feedback is realised by a Python script running on the beamline control computer and the deviations between undulator peak energy and DCM position are $<$ 2eV over the entire scan range of an EXAFS scan.

The performance of the beamline will be presented together with some selected examples from user beamtimes which are suited to illustrate the motivation of the beamline design. A short final part of the presentation will discuss the future conditions for a bulk sample XAFS beamline like P65 on a diffraction limited storage ring with 10-30 pmrad emittance. Ray tracing results show that in fact the fundamental parameter like flux, energy resolution, energy range and the thermal load on the optics would not change significantly. The beamsize of an unfocused beamline would shrink slightly to approximately $0.5*0.5$ mm^2(1^{st} undulator harmonic) and the flux density grow accordingly.