Beamline

You can find a list of P10s individual setups on the next pages.

P10 scope

The Coherence Beamline  P10 is situated in sector 7 of PETRA III. It utilizes a 5m long U29 undulator and operates in the medium-hard X-ray regime (5-20keV).

It is dedicated to experiments using coherent hard x-rays and to advance its major experimental techniques:

1. X-ray photon correlation spectroscopy (XPCS)
   - XPCS is the X-ray analogue of dynamic light scattering (DLS) in the visible light range. By monitoring changes of 'speckled' diffraction pattern in the time domain, this technique allows it to study slow collective motions on length scales unobservable by visible light.

2. Coherent diffraction imaging (CDI)
   - CDI is an X-ray imaging technique which uses phase retrieval algorithms to reconstruct small objects from a coherent X-ray scattering pattern. Using advantages of X-rays, like e.g. element sensitivity or the high penetration depth, it is possible to image objects with a resolution of several tens of nanometers or to look at strain fields inside of nano-crystals.

The P10 beamline is located at a low beta section and takes advantage of the extreme brightness of the PETRA III storage ring. Currently, the PETRA III synchrotron is operating at 100-120 mA in top-up mode.

Overall sketch of the beamline

P10 consists of three hutch: The optics hutch and experimental hutch 1 and 2.

Currently, the optics hutch contains a standard PETRA III high heat load monochromator and a pair of horizontally reflecting, flat (R > 100km) mirrors. In addition, it is foreseen to get pink beam capability at the beamline (the high heat load mirror is still missing).

The first experimental hutch EH1 houses three experimental setups:

- The USAXS setup to study dynamics of soft matter systems with a sample-to-detector distance of ~21.3m and relatively large beam sizes.
- A 6-circle diffractometer which allows to reach large scattering vectors Q
- A vertical SAXS setup in combination with a HAAKE Mars Rheometer. This setup is no longer available for external users as of 2019.

The second experimental hutch EH2 houses the standard sample environment of the beamline and the GINIX setup designed by the group of Prof. T. Salditt of the University of Göttingen. The standard setup and the GINIX setup are movable on air pads and can be exchanged.

- The second experimental setup uses KB focusing optics (focal size ~300x300 nm^2) in combination with waveguides to produce very small (down to 10x10 nm^2) divergent beams for holographic imaging experiments.

P10 - some general aspects
Photon energy gap

P10 operates with an effective energy gap in between ~10.5keV to ~11.5 keV since the specification for the minimum undulator gap of 9.5mm could not be reached. The actual minimum gap is ~9.8mm. This shifts the lower energy cutoff for the first harmonic to ~3.8 keV (or ~11.5 keV for the 3rd harmonic). The increase of the 1st harmonic cutoff is not a problem for P10 but the energy gap might cause problems for some experiments.

General components EH1

EH1 is a 12m long hutch situated 67-79m from the source.

The first 3m of the hutch are dedicated to house a set of shared optical components for the complete beamline. The first element in EH1 is a combination of beam positioning monitor (BPM) by FMBOxford and diamond window situated on a granite block. The beam position is estimated from the backscattered intensity of 0.5 µm thick foils (Titanium or Nickel). The water cooled diamond window (5mm diameter; 60µm thick) is connected to the BPM. This is the only window of the beamline separating the ring vacuum from the beamline vacuum. It is possible to stabilize the beam position at the BPM using vertical and/or horizontal feedback programs when being in double-crystal configuration.

These components are followed by an optical table that houses different optical components. The first element is a passively cooled slit system. The second element is a dual fast shutter system for 2D detectors. One system is based on amplified piezo actuators with ~1ms response time and the second system is based on magnetic coupling (~30ms). The fast system has a small opening of ~0.7 mm and can be moved out of the beam by a linear translation.

This is followed by an absorber system which consists of two linear translations. Each translations is equipped to hold 9 different absorbers. The center position is left empty on both stages and two different materials are mounted on the different sides. One half holds Silver absorbers for X-ray photon energies above 12 keV and the other half holds double-sided polished thin Silicon crystals for lower X-ray energies.

Finally, a monitor unit which is based on scattering of a thin Kapton foil at 90° in combination with a Cyberstar scintillator detector allows to monitor the incident intensity on the sample.

General components EH2

The first general beamline components in EH2 sit on a 2.7m long optical table in EH2, which is similar to the optical table at the beginning of EH1. The table can be moved out of the beam to install a DN200 (8" tube ID) flight tube, which allows to have a sample in EH1 and use the detectors in EH2. The optical table in EH2 carries a piezo driven water cooled closed loop slit system followed by a retractable monitor device to define and monitor the beam direction. The maximum nominal slit opening is 10x10mm² and the resolution of the slit position is 0.2 microns. Similar to EH1, the monitor unit is based on scattering of a thin Kapton foil at 90° in combination with a Cyberstar scintillator detector.

These components are followed by a beam deflection unit (BDU) to enable studies on liquid surfaces. This BDU uses two Ge(111) crystals to slightly tilt the beam downwards. This enables studies of liquid surfaces in grazing incidence conditions (i.e. no full reflectivities up to large angles, but enough to reach incidence angles of up to 2x the critical angle of most liquids).

The next element is a micro-focusing lens changer (1D & 2D focusing capability). It allows to reach focal spot sizes between 3-5 microns in both, vertical and horizontal, direction. The lens changer (transfocator design) is equipped with 12 stacks of interchangeable Beryllium lenses, which allows to have the correct lens combination for the desired focal distances (of several meter) and for X-ray energies between 5-20 keV. A macro can be used to calculate the best lens combination and best lens-to-sample distance for the chosen X-ray energy.

At the end of the hutch, a 3.5 m long translation mounted on a granite block can be found. The granite block is rotated by ~15° from the perpendicular direction to the beam. This setup allows to rotate the 5m long flight path (standard sample position in EH2) and detectors around the sample position by ~30 degrees in the horizontal direction, which makes it possible to perform coherent scattering experiments at large Q values (~2 inverse Angstrom @ 8keV).

Optics hutch

USAXS setup

6-circle Diffractometer

4-circle SAXS/WAXS setup

GINIX setup

Infrastructure (Labs, etc.)

The P10 coordinate system