PETRA III beamline P61B: Extreme conditions science using the LVP

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Probing the structure and properties of materials at extreme conditions of high pressures and temperatures *in situ* using X-ray diffraction techniques is an increasingly demanding requirement, particularly in Earth and materials sciences. Regular *ex situ* studies using the Large Volume Press (LVP) simply do not allow monitoring of the many processes that may occur in a compressed and heated sample, nor can the pressure, temperature, stress and strain (rate) be accurately recorded over time. Also, real-time imaging of the sample, as it undergoes changes at extreme conditions, is only possible using a synchrotron source. In contrast to LVP techniques, the diamond anvil cell (DAC) technique allows for reaching extremely high pressures. However, sample volume is restricted, preventing careful study on more than 1 phase in the sample (phase-mixtures) and on transport & mechanical properties in samples with sufficient number of grains/large grain size.

At the PETRA III P61B beamline, a 6-ram LVP is in operation since 3 years (Fig. 1a,b). This state of the art 15 MN press has extremely precise ram control for reaching high pressures with a significantly low rate of anvil breakage. Routine experiments are possible up to 20 GPa (Fig. 1c), with a special set up envisaged to reach 25 GPa in kawai '6-8' geometry. Even higher pressure generation is possible with modified user-provided WC anvils to reach 40+ GPa with >2000 K heating, and with sintered diamond anvils to reach 60+ GPa.

In addition, cubic '6-6' compression geometry is offered to synthesize nearly cm-sized samples up to 4-5 GPa and generate pressures up to ~15 GPa for controlled rock deformation (anisotropic compression). The LVP at beamline P61B is therefore well-suited for extreme conditions research using versatile set ups. The beamline also offers a fully equipped sample preparation laboratory with stereo-microscopes, a high-T vacuum furnace, a CNC for parts machining, a top-range benchtop diffractometer, amongst other needs.

First beam is expected to be available since August 2019. Commissioning will therefore be underway using a solid-state, high-purity Ge detector for ED-XRD powder diffraction and an X-ray microscope for imaging (Fig. 1d). The instruments are mounted on a temporary positioning system (i.e. table with stages) and will be used until the delivery of the complete positioning system, built by Kohzu, sometime in April 2020. A second Ge-detector will then be added. The first call for user beam time will likely be announced in the coming months, pending the usability of the temporary detector set up for *in situ* high-pressure experiments in the LVP.

The LVP beamline will operate with beam on a 50% basis with HZG. Therefore, the LVP is also available for *ex situ* studies. Proposals for *ex situ* studies can be submitted anytime and will be reviewed by the beamline manager. Waiting time for experiments without beam is much less than with beam (1 versus 6 months).

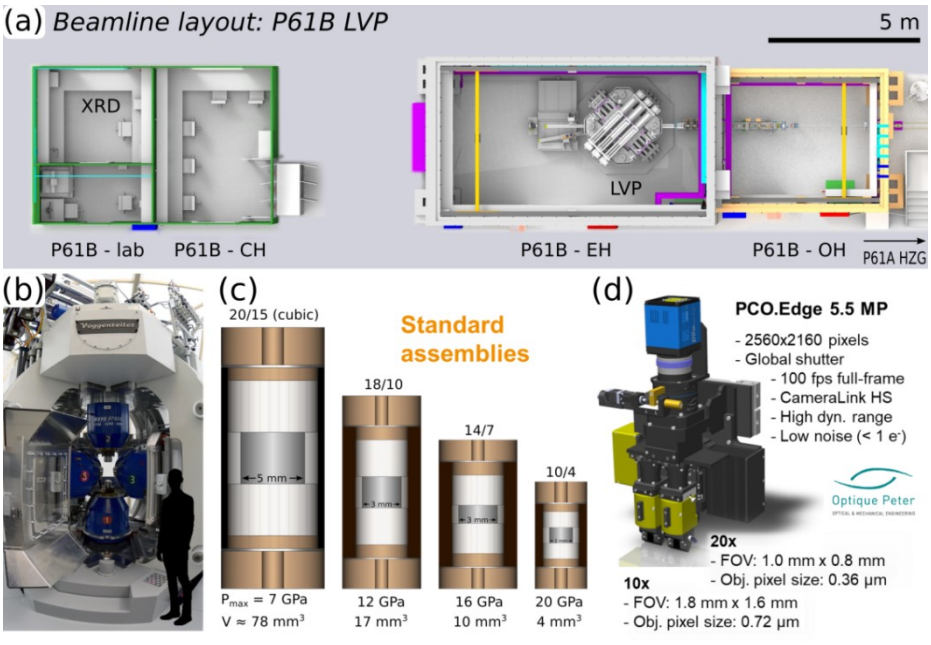

Figure 1. Beamline P61B. (Not shown are twin HP Ge-SSD for ED-XRD)
(a) Beamline layout.
(b) 6-ram LVP.
(c) Standard assemblies for users.
(d) Whitebeam X-ray microscope with dual objectives and fast sCMOS camera.