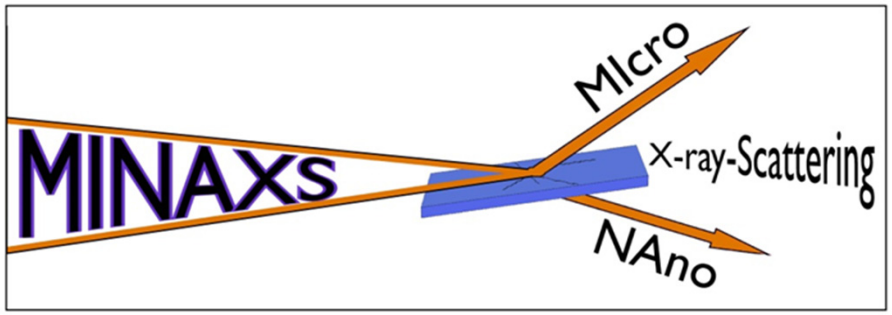
Flexible X-ray Focusing using CRL Transfocators for *in situ* GI-SAXS/WAXS Experiments at MiNaXS/P03



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FS-PETRA-D, DESY, Notkestr. 85, D-22607 Hamburg, Germany

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

MEDSI 2020
Chicago, 28.07.2021

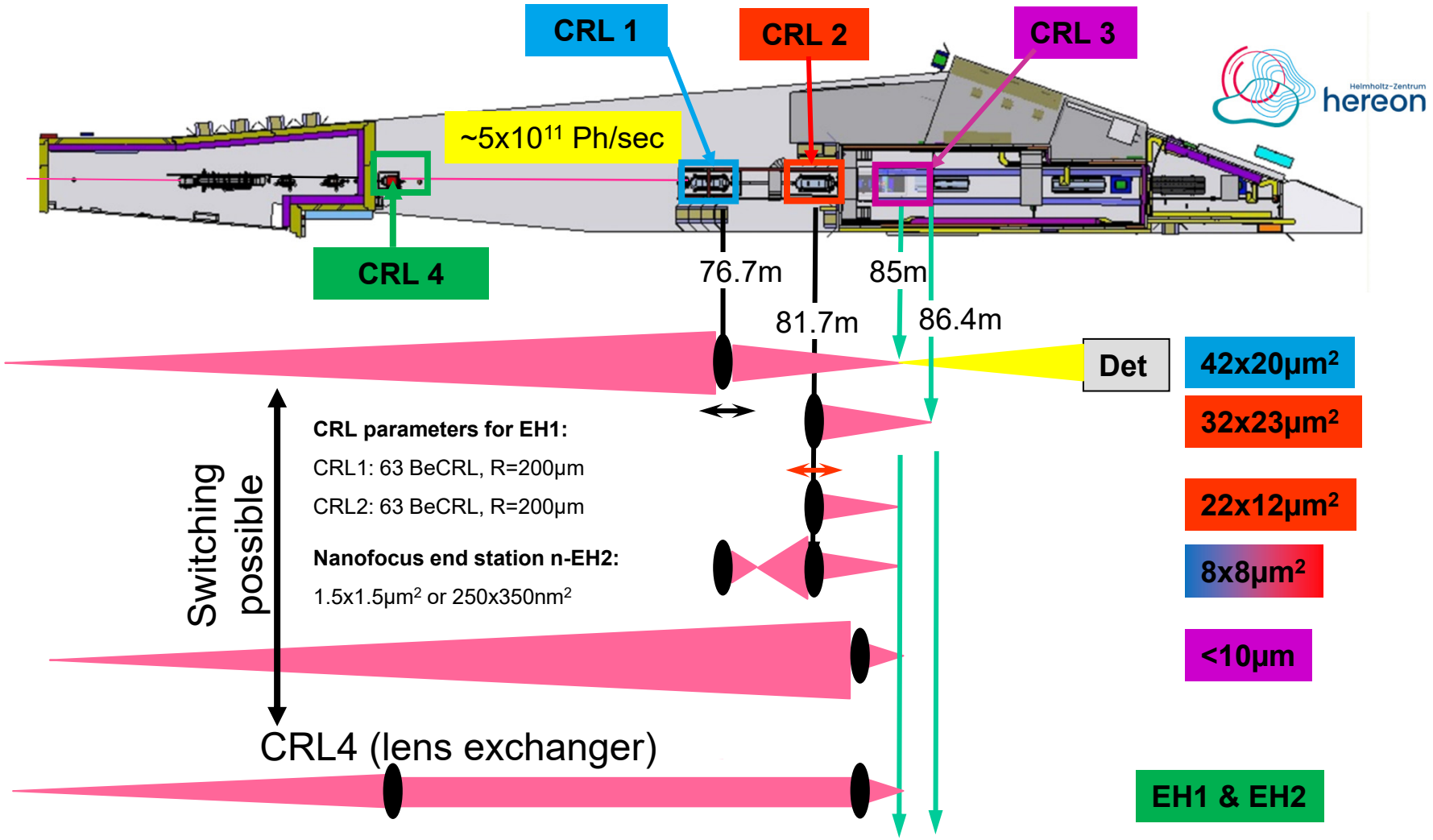
MEDSI CHICAGO 2020

DESY.

Outline

- Layout – Different µ-focussing schemes
- P03 Experimental µ-focus hutch (EH1)
- CRL3 frontend with 1D - lens system
- New CRL4-system
- Summary

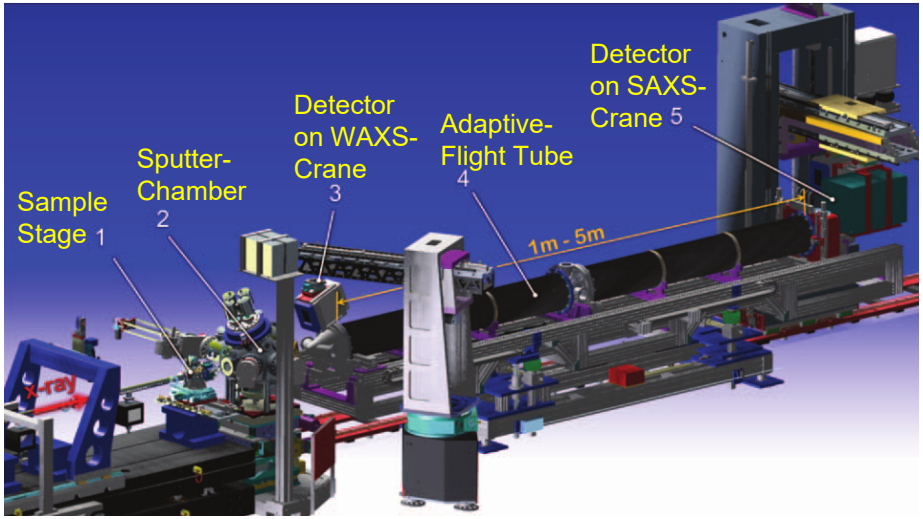
Layout – Different µ-focussing schemes

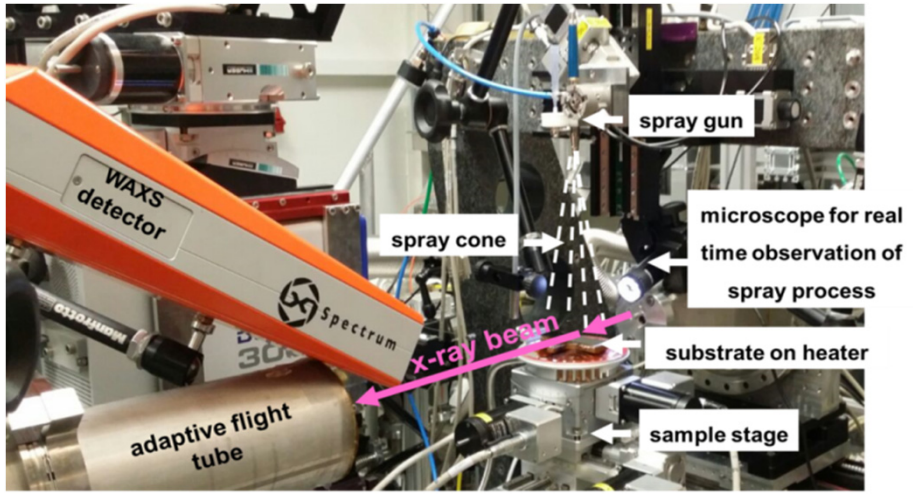


Krywka et al., J. Appl. Cryst. 45, 85 (2012).
Santoro et al., Rev. Sci. Instr. 85, 043901 (2014).
Buffet et al., J. Synchr. Rad. 19, 647 (2012).
Roth et al., J. Phys.: Cond. Matter 23, 254208 (2011).

P03 Experimental µ-hutch

- micro focused beam with low divergence and high flux (Energy: 9-21 keV)
- extremely flexible GI-(U)SAXS/GI-WAXS on heavy load goniometer (<180 kg)
  - (SDD: 10mm ~ 10m ➔ resolution: from some Å up to larger then 1 µm)
- nanostructural evolution *during* industrial-relevant coatings/treatments



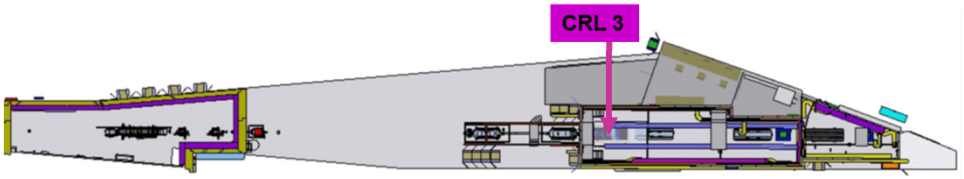


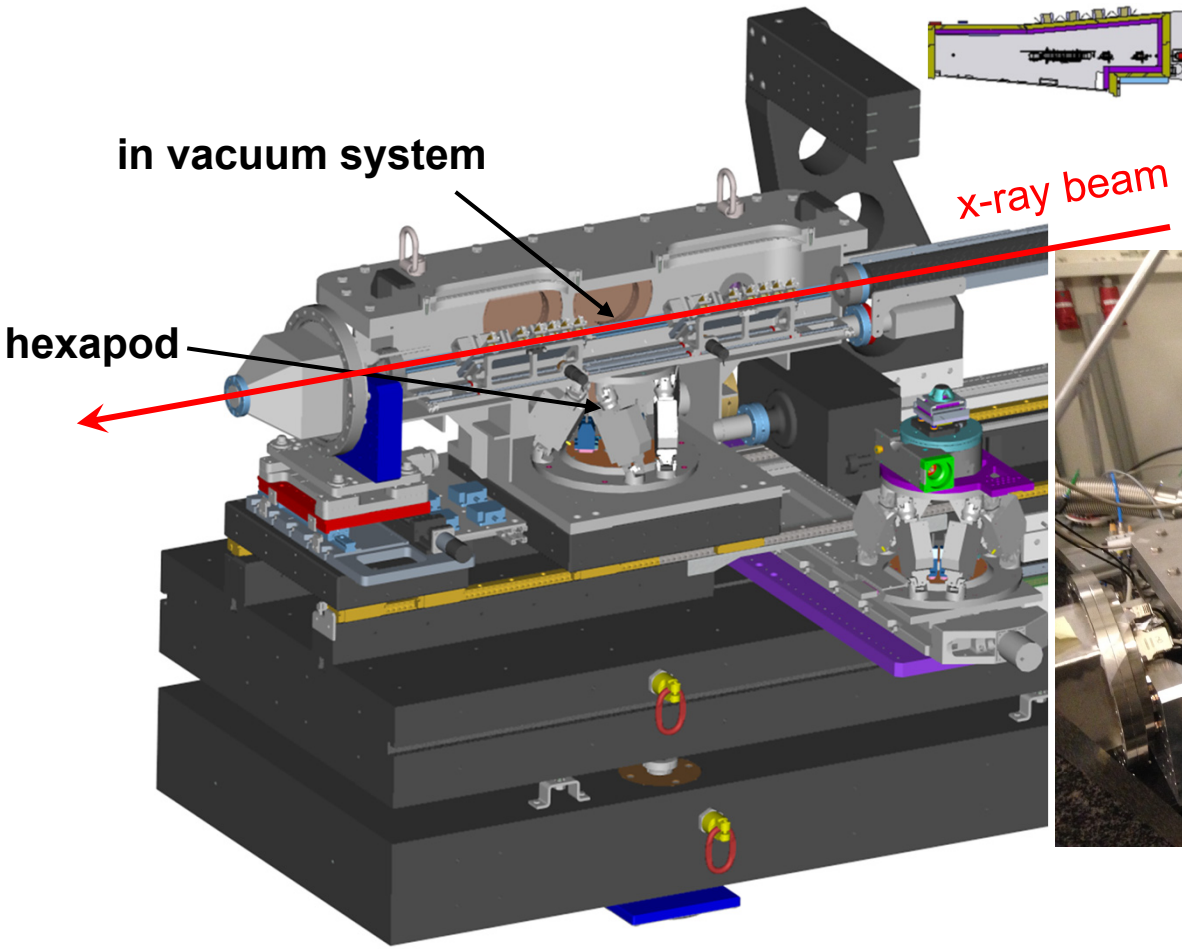
Spectrum

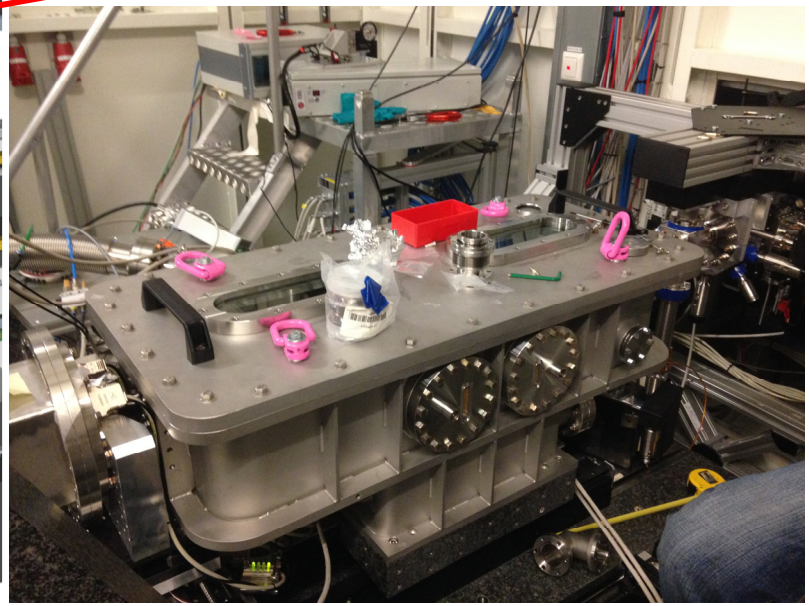
- Goal:
- smaller micro-focused beamsizes
- higher photon flux

Döhrmann et al., Rev.Sci. Instrum. 84, 043901 (2013).

CRL3 frontend with 1D - lens system

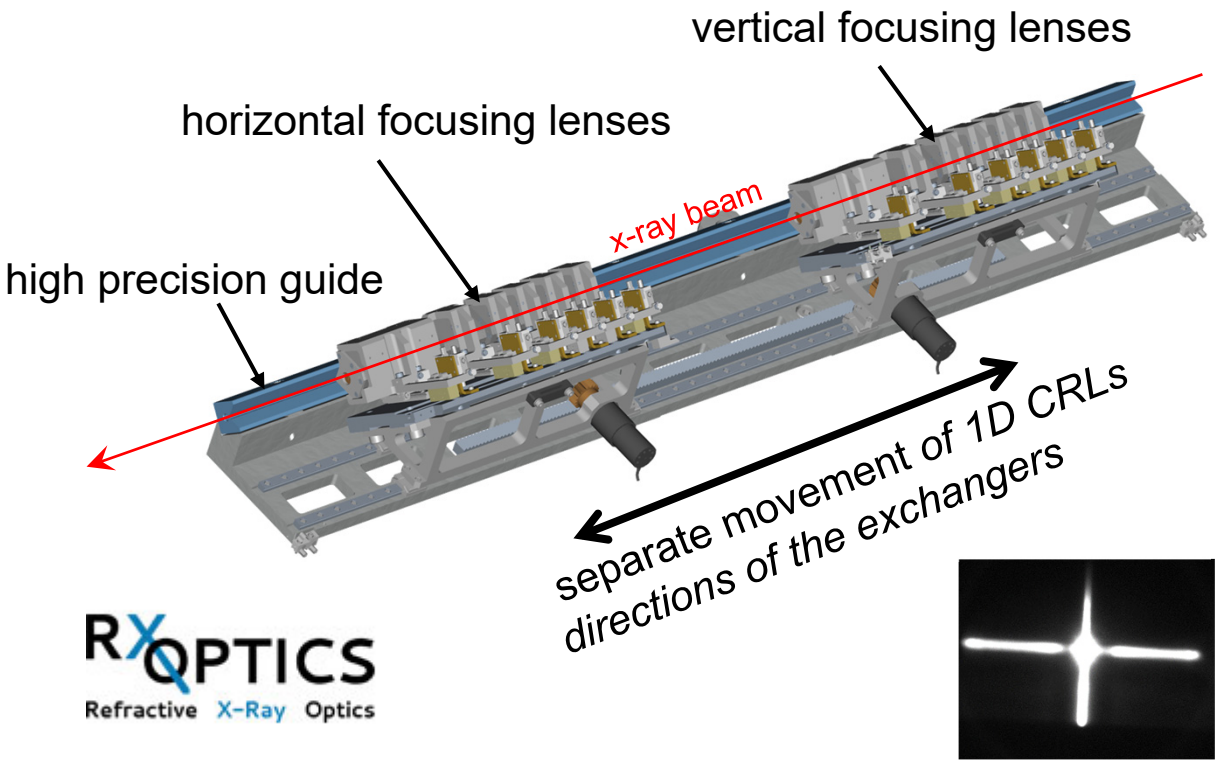


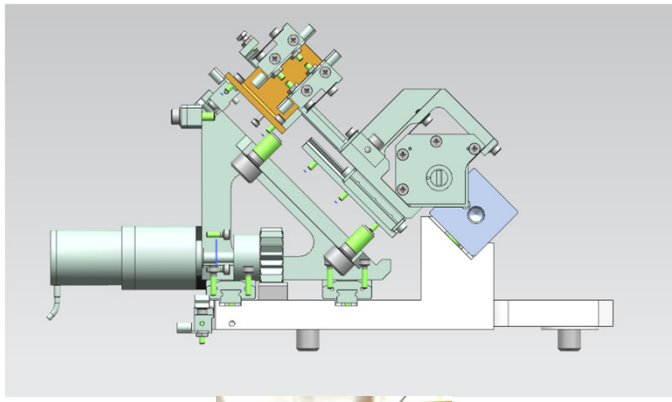


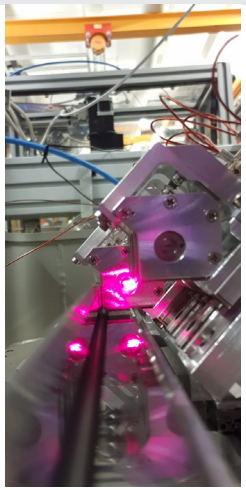


- two CRL-systems equipped with two sets of 1D lenses (63 lenses each)
- translation of the complete CRL system on linear guides

CRL3 1D - lens exchanger system







RX OPTICS
Refractive X-Ray Optics

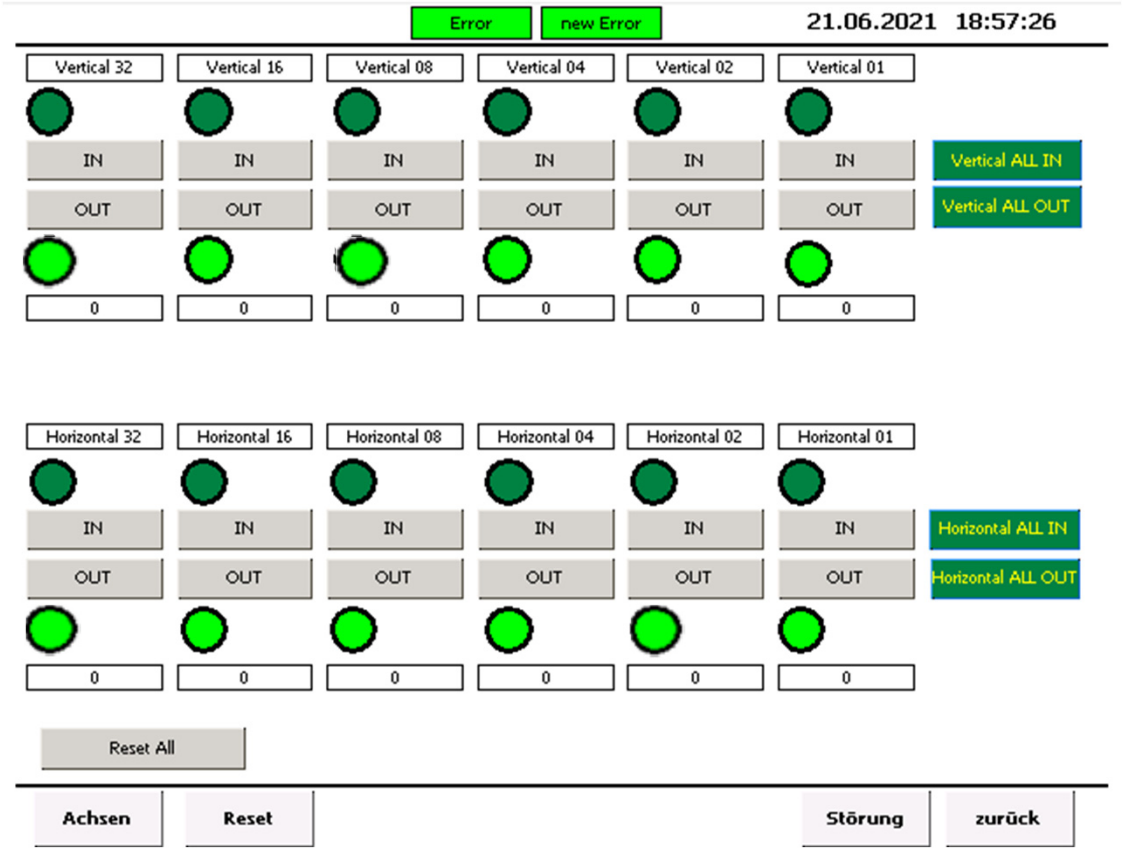
- independently lens exchanger movement => tuning focus position
- lenses can be moved by piezo motors
- High precision guide for alignment

Control software for CRL3

- development and implementation of control software and GUI
- TwinCAT 3 based
- Beckhoff controller and clamps

BECKHOFF

TwinCAT®

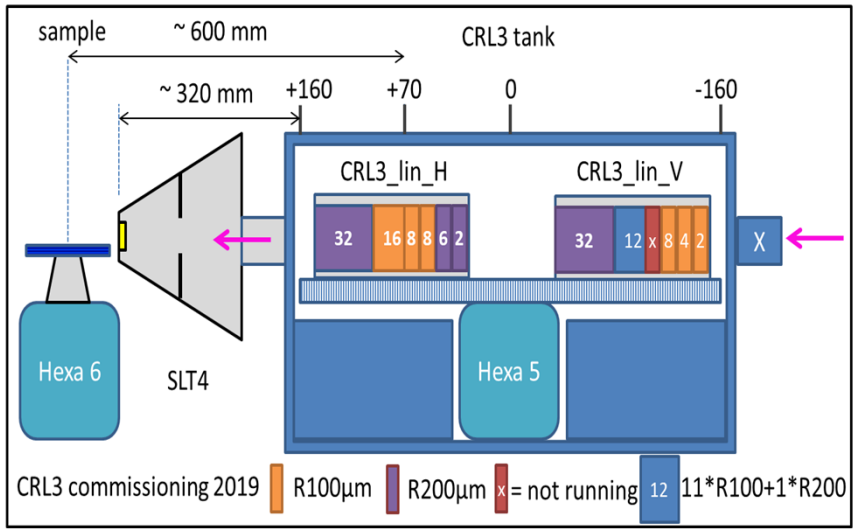


Beamsize measurements

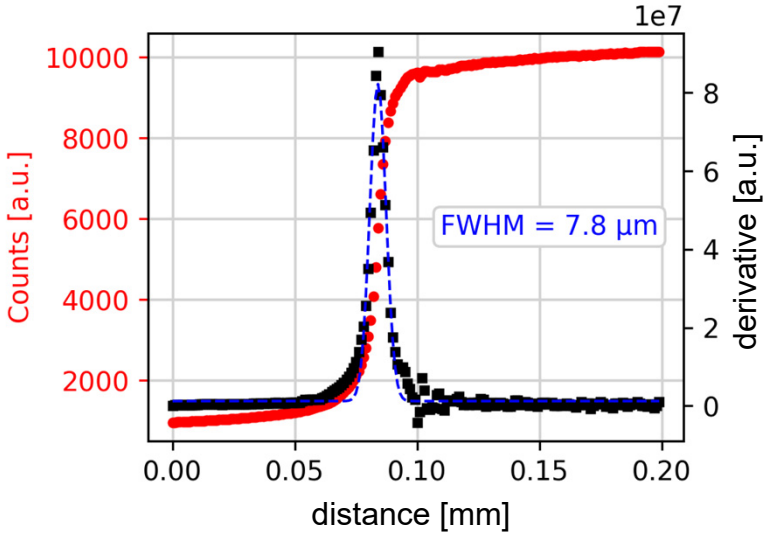
- knife edge Scans of the focused beam at sample position at energy of 11.8 keV
- @13keV beamsize of 7.7 x 9.6 µm
- N_{horz}: 27 lenses ; N_{vert}: 19.5 Lenses (R=100µm eq.)
- focal lenght:

  horizontal: 470 mm

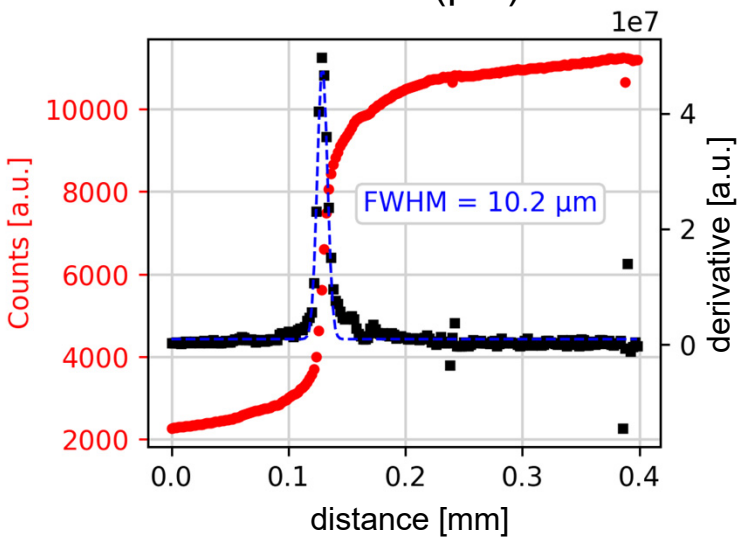
  vertical: 770 mm



horizontal (µm)



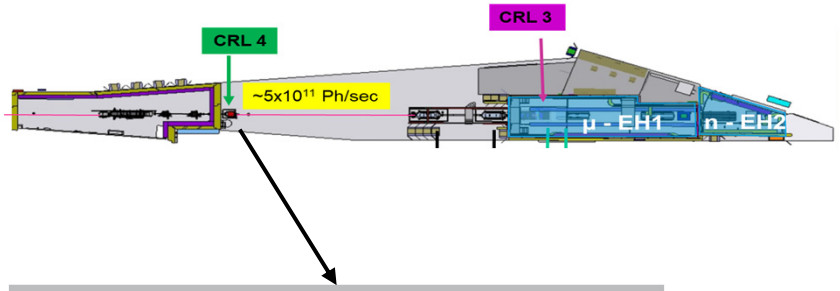
vertical (µm)

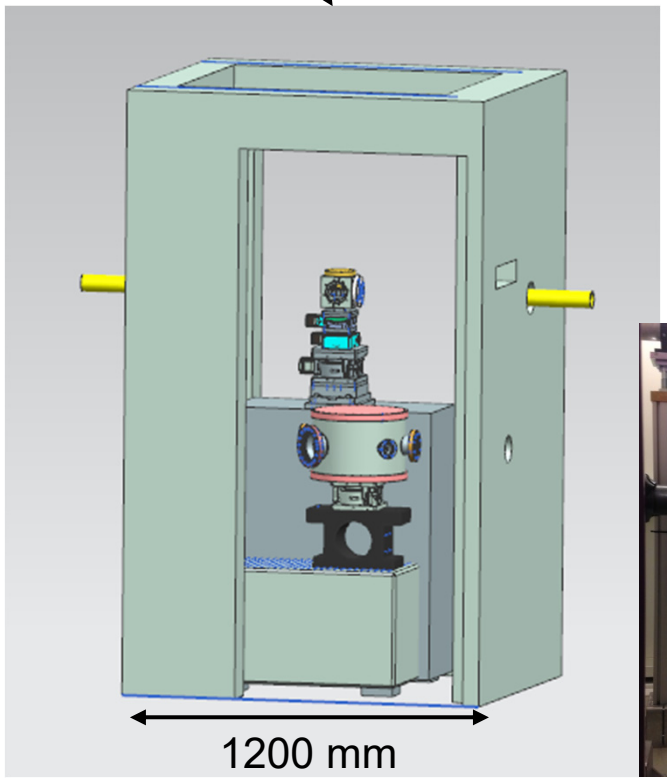


New CRL4-system for parallelizing of the beam

Aims:

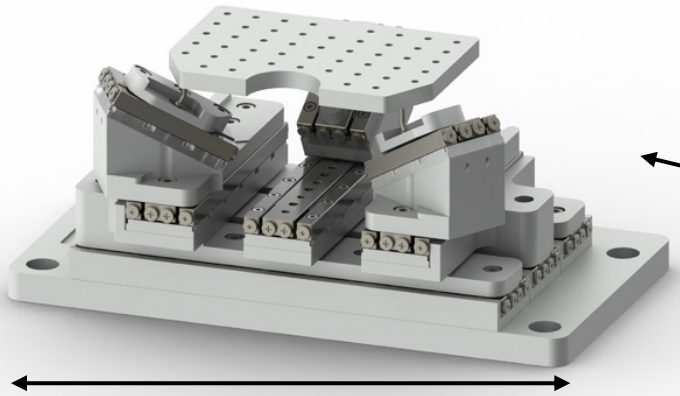
- condense the beam before focusing
- Increase flux => expected flux gain factor: 2-4
  - Engineering task/problem
    - Positioning of the lenses
  - Solution
    - high precision device
- Boundary: secondary optics hutch shared with P02
  - Compact design is needed



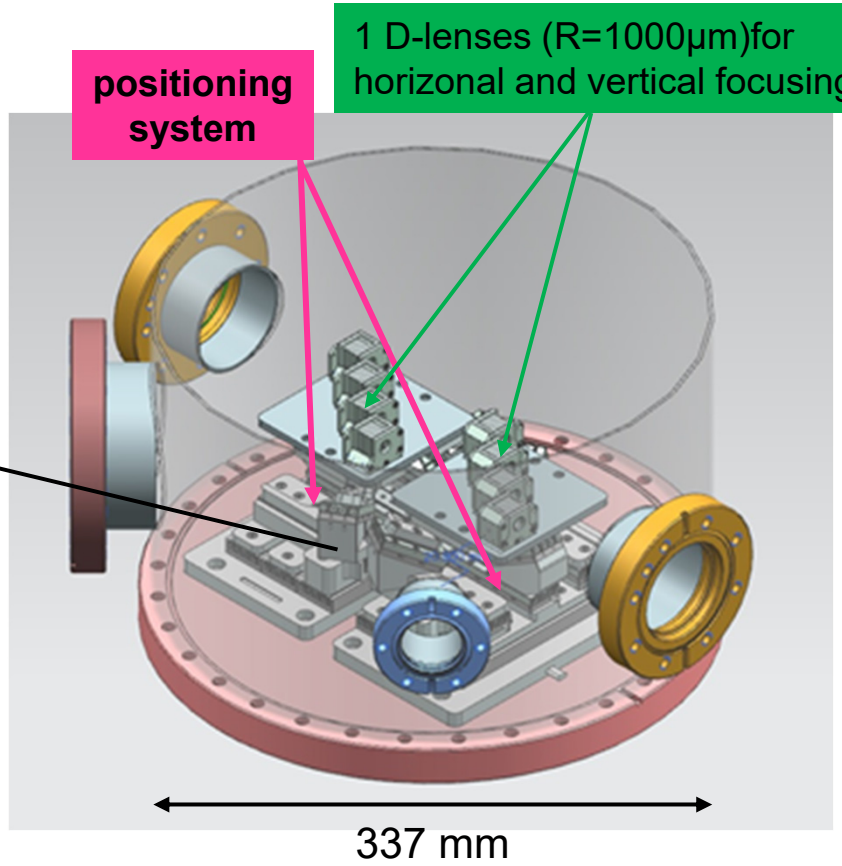


Vacuum Chamber with positioning system

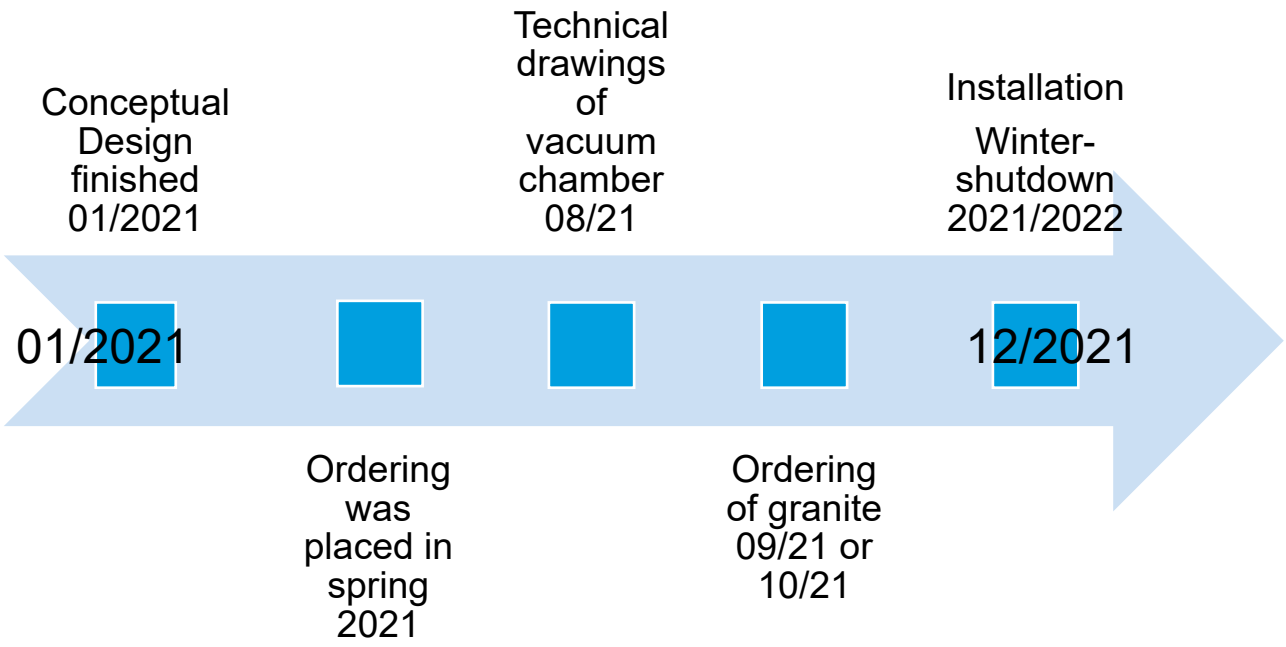
- CAD model design in NX 10 software
- design and arrangement of the positioning system
- a „SMARPOD P-SLC-24“ from SmarAct



SmarAct



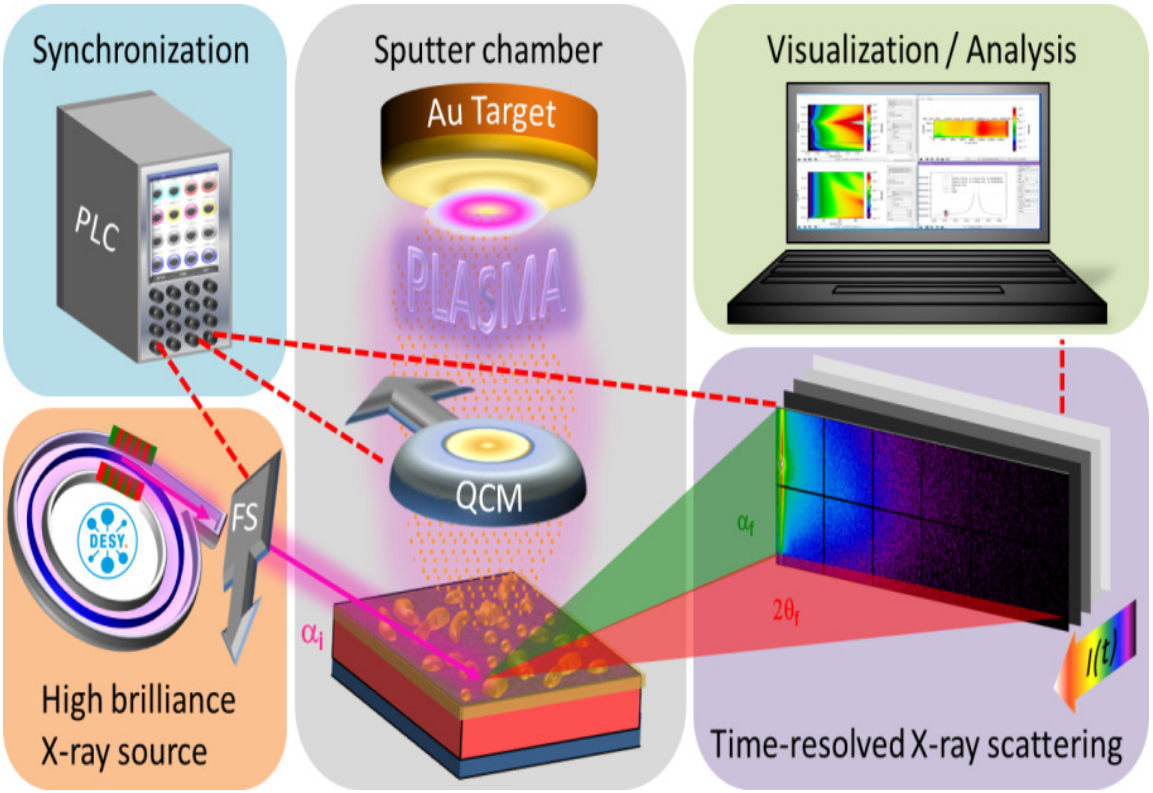
Time plan

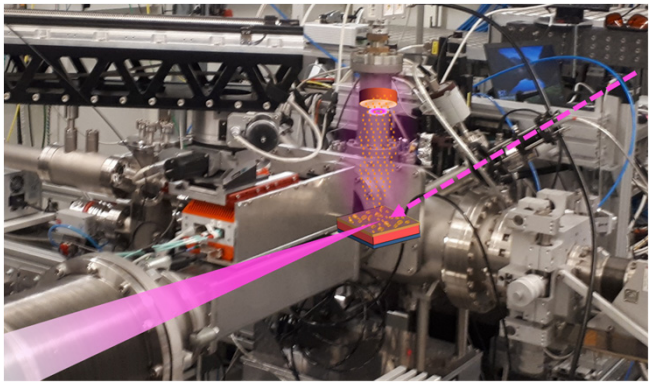

Conceptual Design finished 01/2021
Technical drawings of vacuum chamber 08/21
Installation Winter-shutdown 2021/2022
01/2021
12/2021
Ordering was placed in spring 2021
Ordering of granite 09/21 or 10/21

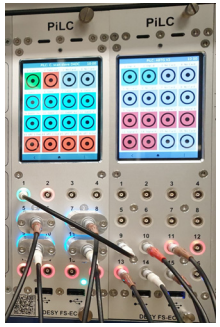
High-frame rate *in situ* GISAXS

2000 fps / WORLD RECORD for synchrotron-based *in situ* GISAXS !

> increase the time resolution







Spectrum

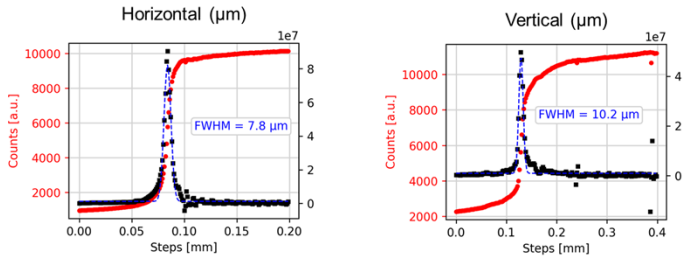
Schwartzkopf, …,Rubeck…, Roth, Nanoscale Horizons, 6, 132 (2021).

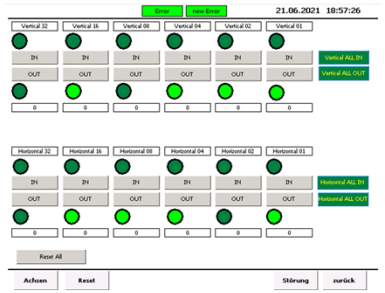
RO 4638/1-1/2, FA 234/23-1/2 and MU 1487/18-1/2

Summary

CRL3:

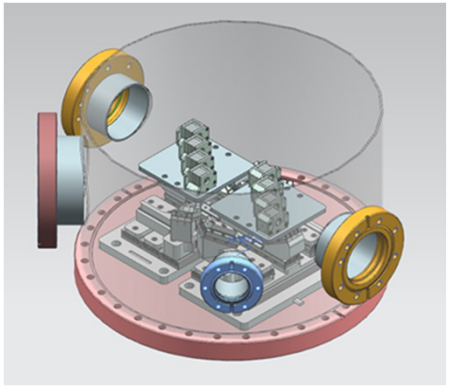
- showed that we can decrease the beam size by using CRL3
- self written program and GUI in TwinCat3





CRL4:

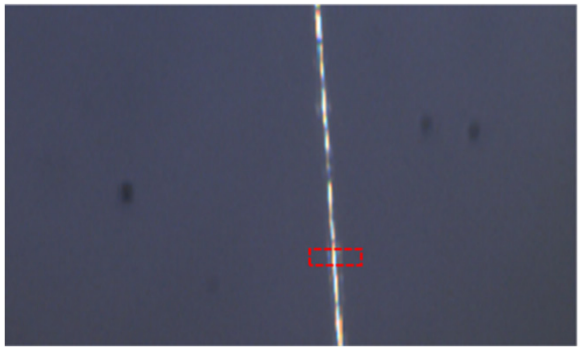
- needed to parallelize the beam before CRL1&2&3
- higher flux can be achieved



Future Perspectives

CRL3: smaller beams

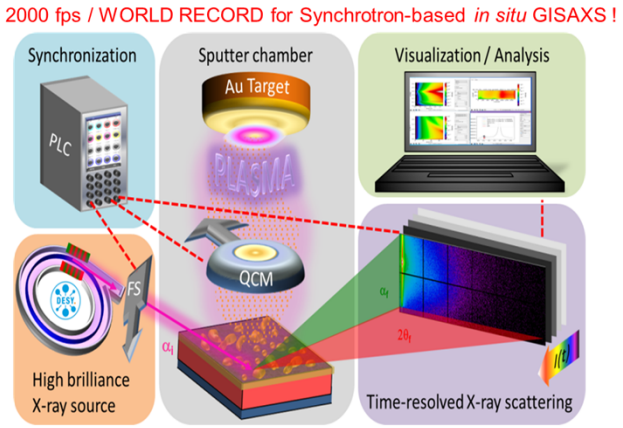
- local analysis of nanostructured or micro-sized materials
- scanning of heterogenous samples like tissues, bones and fibers



20µm Nylon fiber sputtered with gold

CRL4: higher flux

- higher frame rates for fast kinetics (t < 1ms)
- Industrial relevant deposition rates



Thank you!

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Dr. C. J. Brett (former PhD candidate, DESY & KTH)

Dr. Andrei Chumakov

Dr. Benedikt Sochor

M. Gensch (PhD candidate, DESY & TUM)

E. Erbes (PhD candidate, DESY & GAU Göttingen)

C. Harder (PhD candidate, DESY & TUM)

Dr. Qing Chen (DESY & USTC)

E. Tahtali (Student)

… and many more…

THANK YOU FOR YOUR ATTENTION!