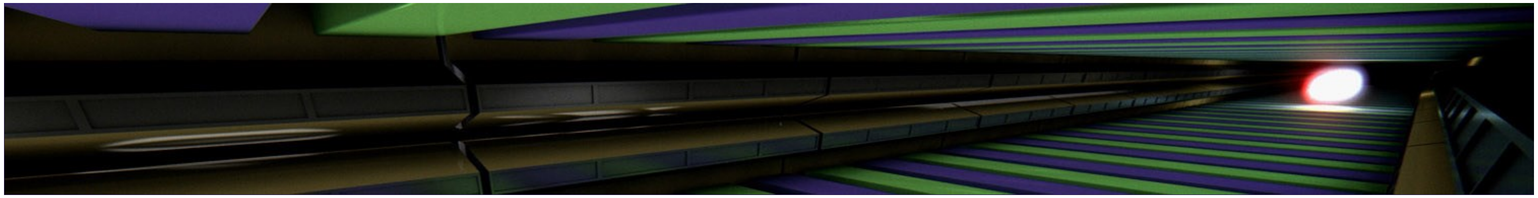

MID: Materials Imaging and Dynamics Instrument

A. Madsen[1,*], J. Hallmann[1], T. Roth[1], G. Ansaldi[1], W. Lu[1,2]

[1] European XFEL

[2] Technische Universität Berlin

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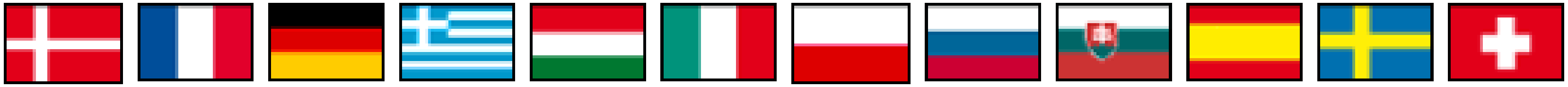
XFEL User Meeting 2014

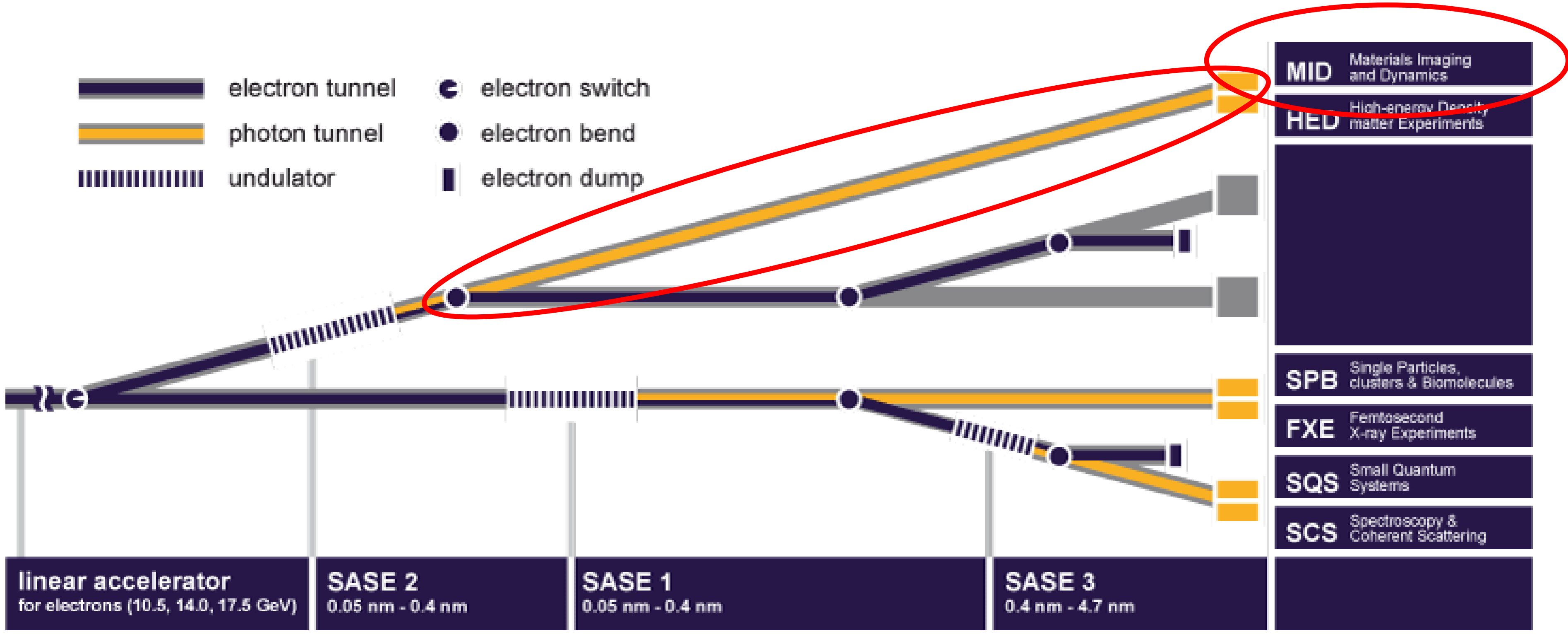


MID Keywords

- ✓ Scattering and imaging with hard X-rays
- ✓ Micro- and nano focused beams
- ✓ Windowless operation
- ✓ Use of a maximum number of pulses
- ✓ Versatile experimental chamber and sample environment
- ✓ Optical pump laser
- ✓ Ultrafast science & X-ray split-delay techniques
- ✓ Coherence & speckle

Facility Outline

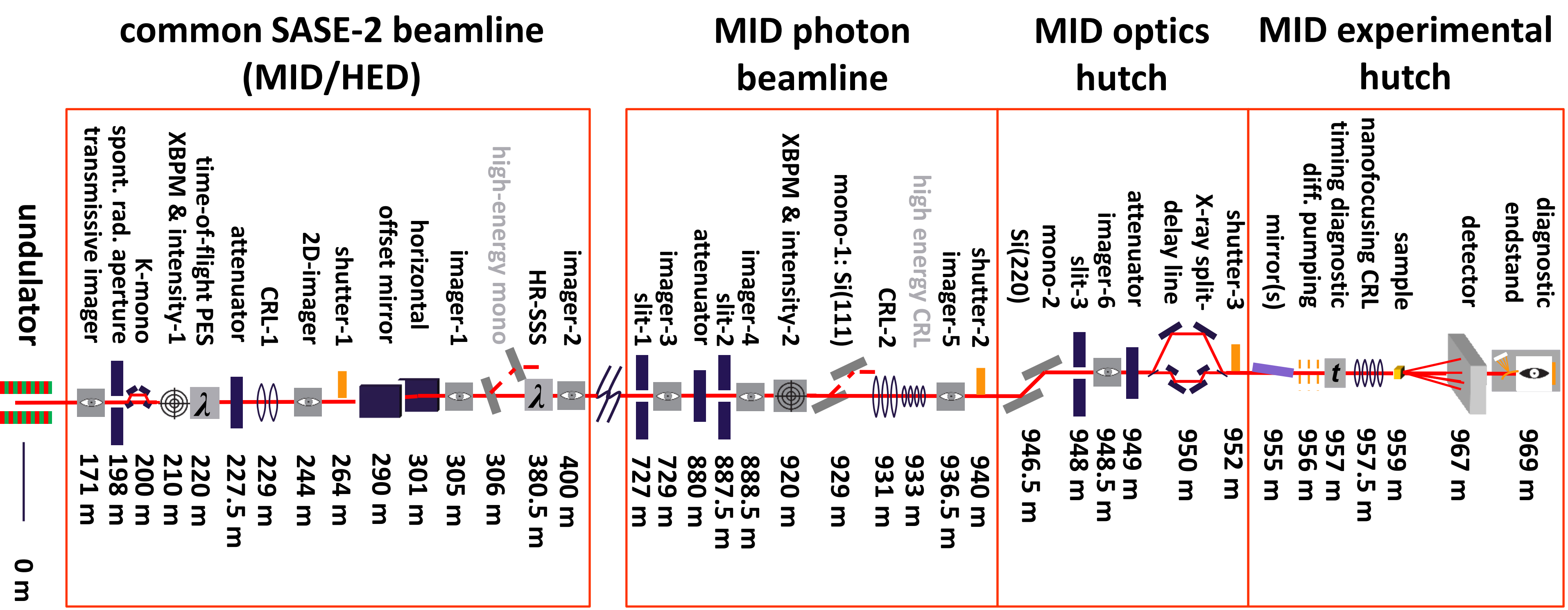
MID @ SASE-2



A. Madsen, XFEL.EU

European XFEL

MID beamline overview



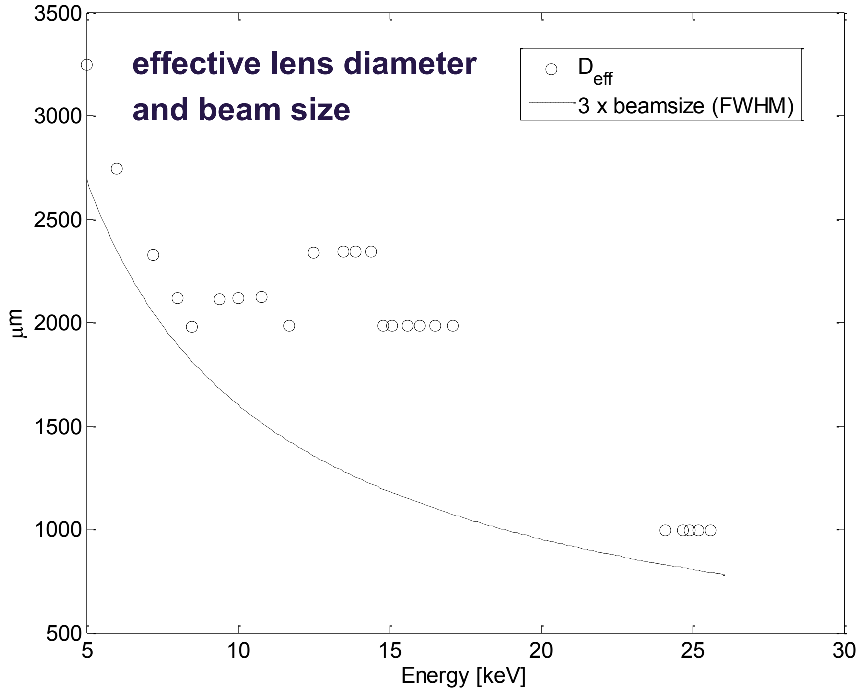
Not shown:

- **MCP at 303m (fine tuning of SASE)**
- **Distribution mirror(s) at 390m and 395m (MID on central branch)**
- **Beam loss monitors**

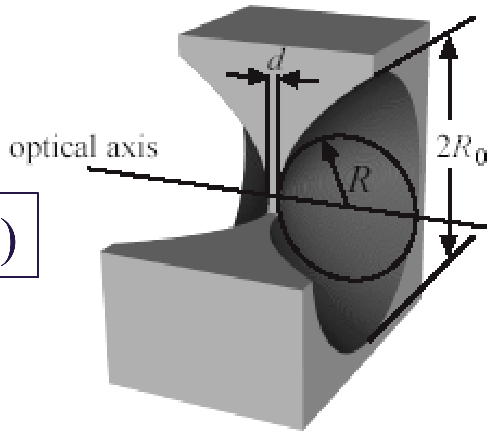
Beryllium Optics for the MID Station

Compound Refractive Lenses (CRL) in Beryllium

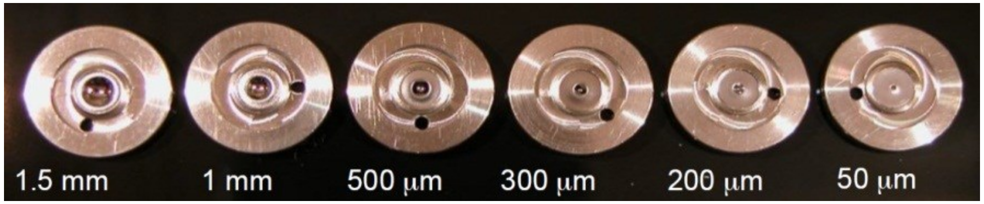
- Be is an excellent material to avoid ablation
- Beam collimation or focusing in the range from ~5 – 25 keV
- CRL efficiency below ~5 keV not good
- Chromatic focusing → Sweet spots in energy
- Allows 7σ (~3*FWHM) to be transported



$$f = R/(2N\delta)$$



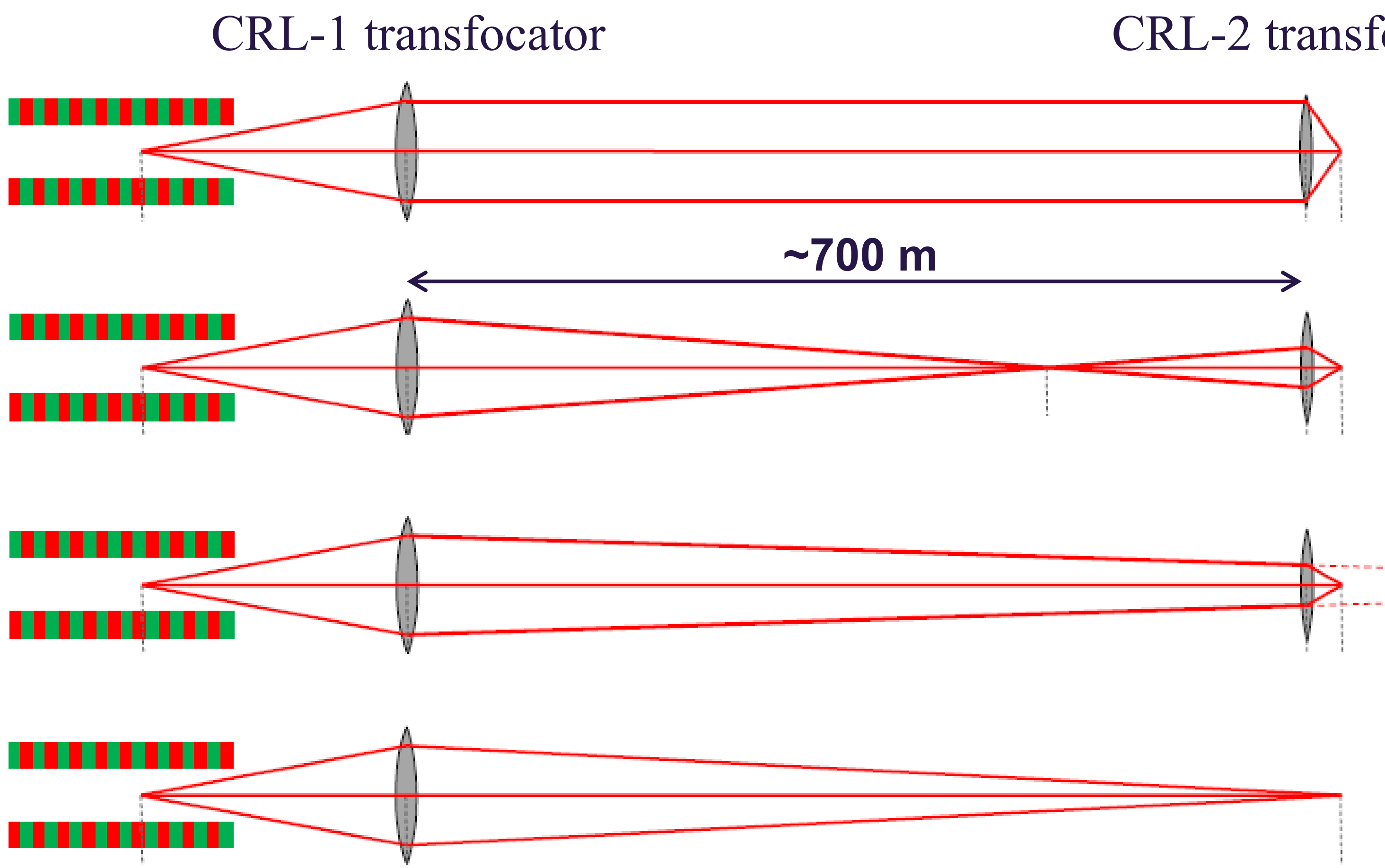
Large radii lenses, up to R > 5mm



B. Lengeler, RXOPTICS, Aachen

European XFEL

Beryllium Optics for the MID Station



Allows beam sizes on sample from 5 – 200 µm and 80-100% efficiency

Range from ~5 to 25 keV (sweet spots every ~500 eV)

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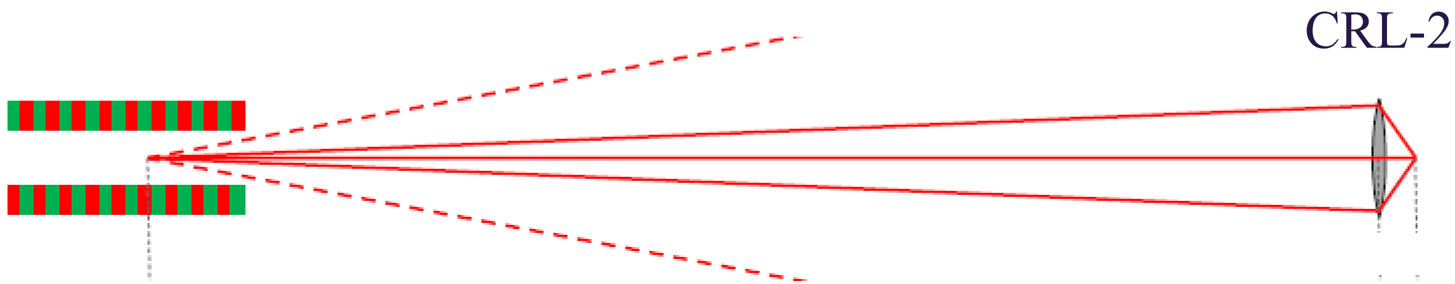
Beryllium Optics for the MID Station



Allows beam sizes 1 – 3 µm with 20-40% efficiency

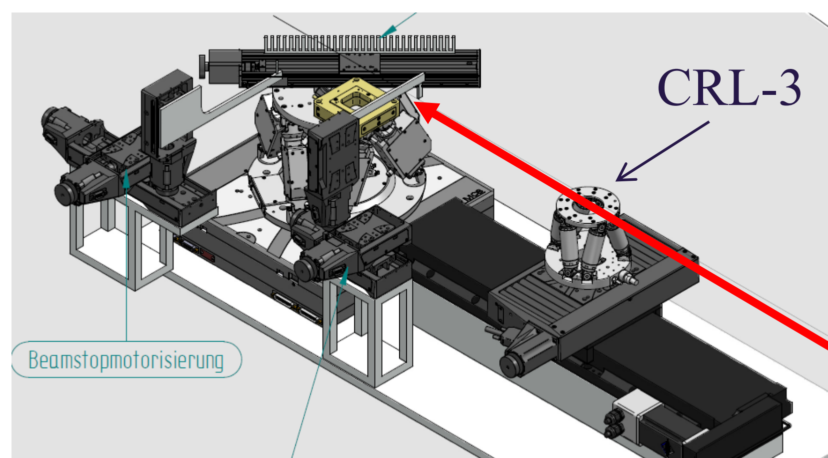
Nano focus option: CRL-3 placed 50-500 mm upstream of sample inside the sample chamber. BMBF project, C. Schroer - TU Dresden

Energy	Beam size (FWHM)
5 keV	187 nm
8 keV	117 nm
12 keV	78 nm
16 keV	58 nm
25 keV	37 nm

Calculation for f=300 mm

Efficiency ~50% with prefocusing

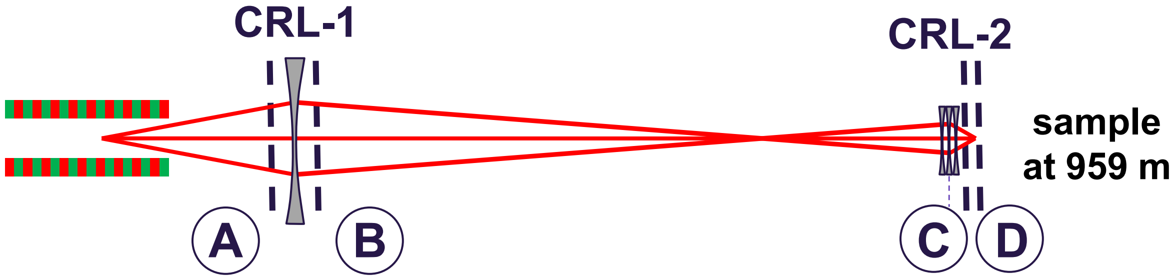
~10 nm focus for f=50 mm at 12 keV



Setup for MEC, LCLS
C. Schroer, D. Samberg, TU Dresden

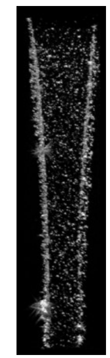
A. Madsen, XFEL.EU

Wave field Simulations: Impact of Be imperfections and impurities

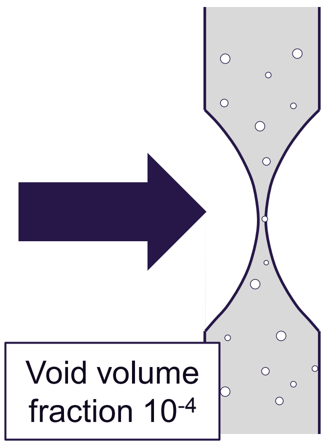


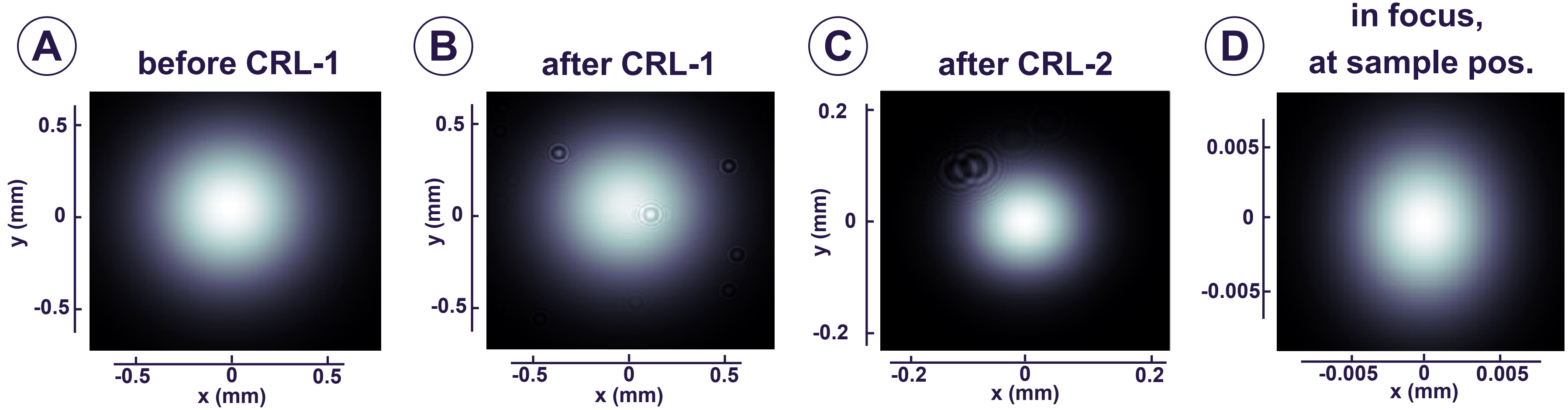
Reconstructed planes

Laminography data, ID19, ESRF (L. Helfen)



Be lens model





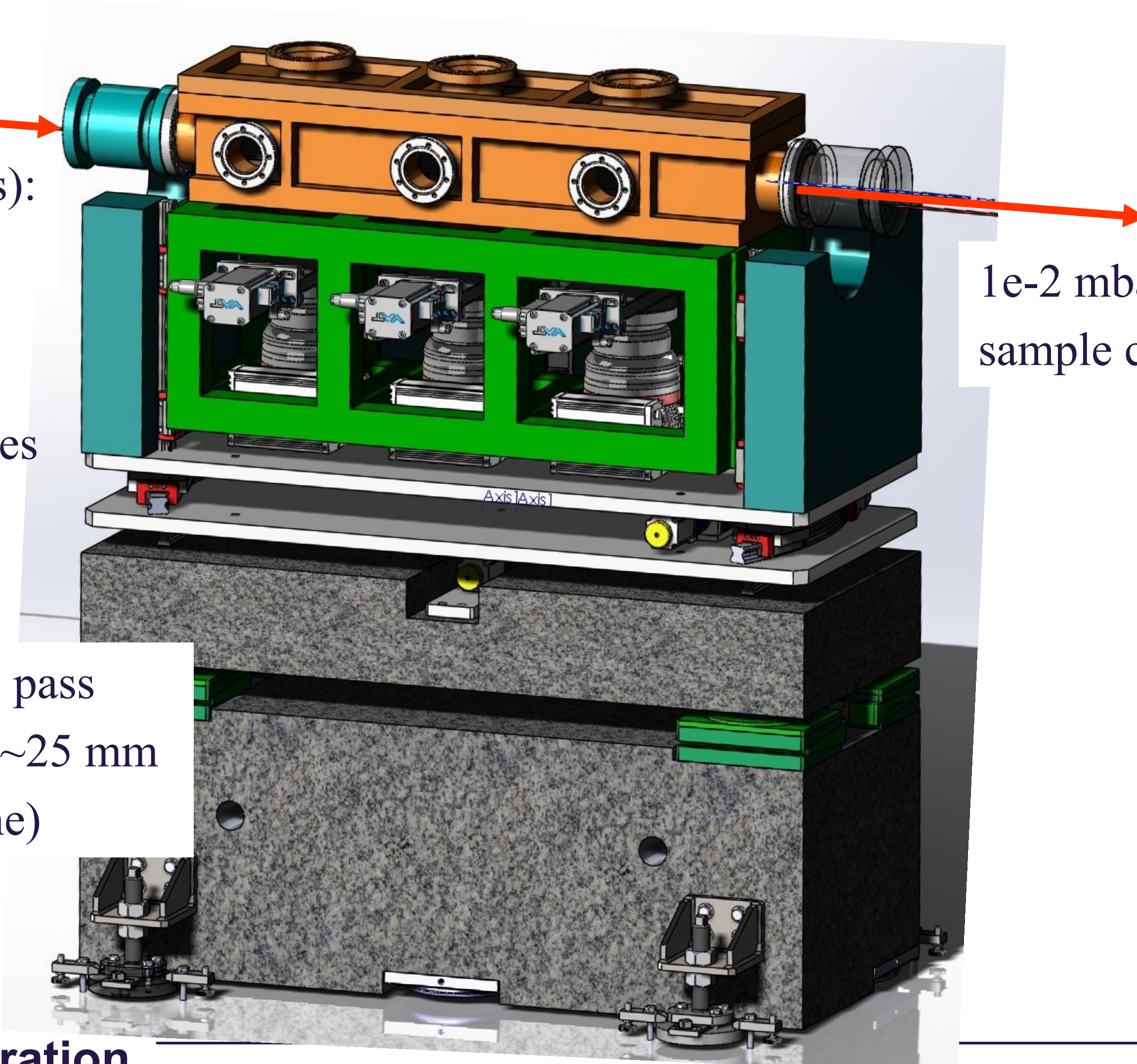
Poster #213 (Friday poster session)

Acknowledgement:
L Samoylova, XFEL.EU Optics group

Windowless Operation

Differential pumping section

HV side (mirrors and crystals):
1e-7 - 1e-8 mbar

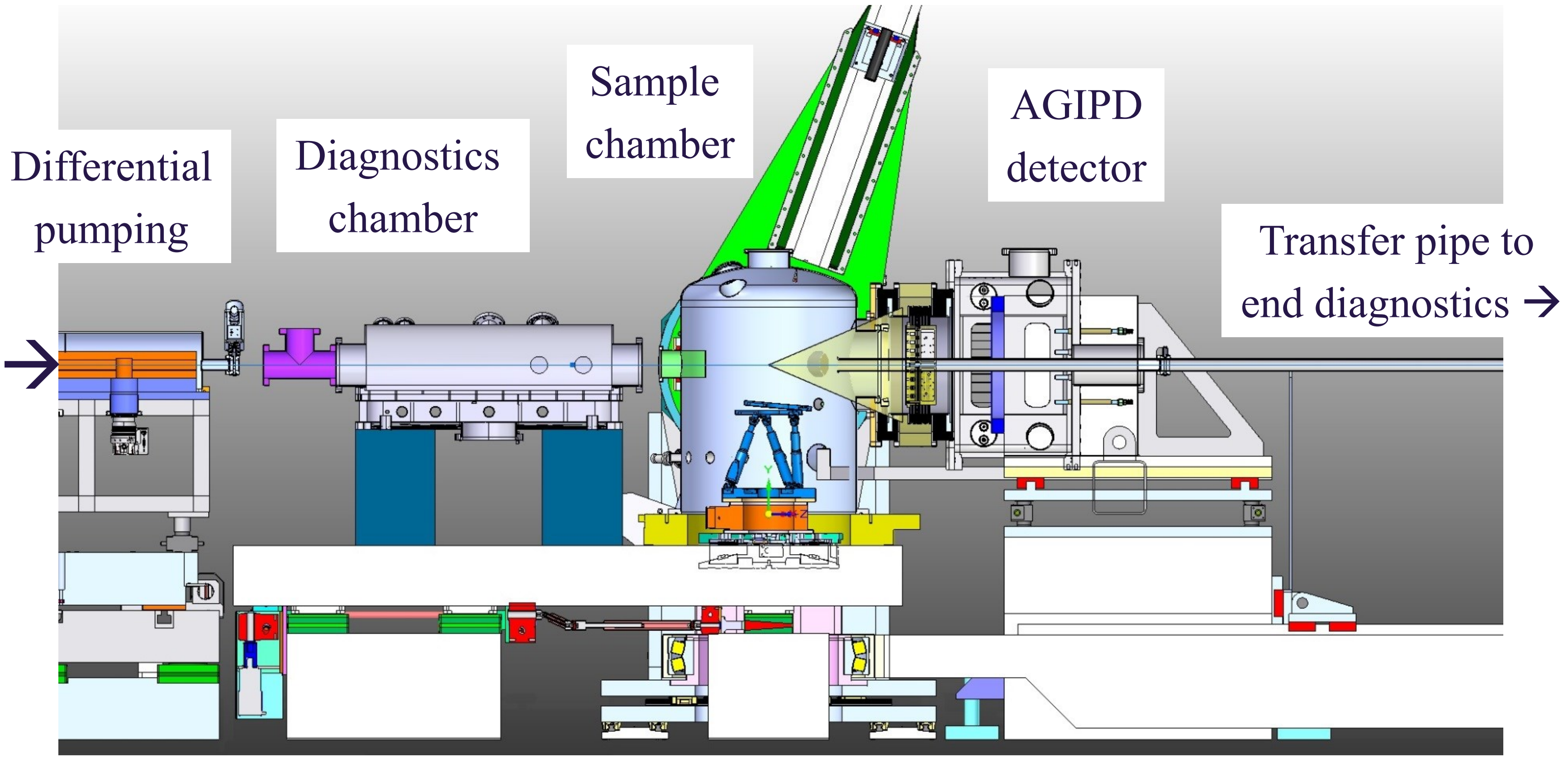


1e-2 mbar
sample chamber

Differential pumping apertures
inside made from B_4C

Must allow two beams to pass
with a vertical separation of ~25 mm
(from Split-Delay Line)

Experimental Setup



Close configuration: AGIPD 0.5 m from sample chamber center

Beam transmitted to end diagnostics via central hole and transfer pipe

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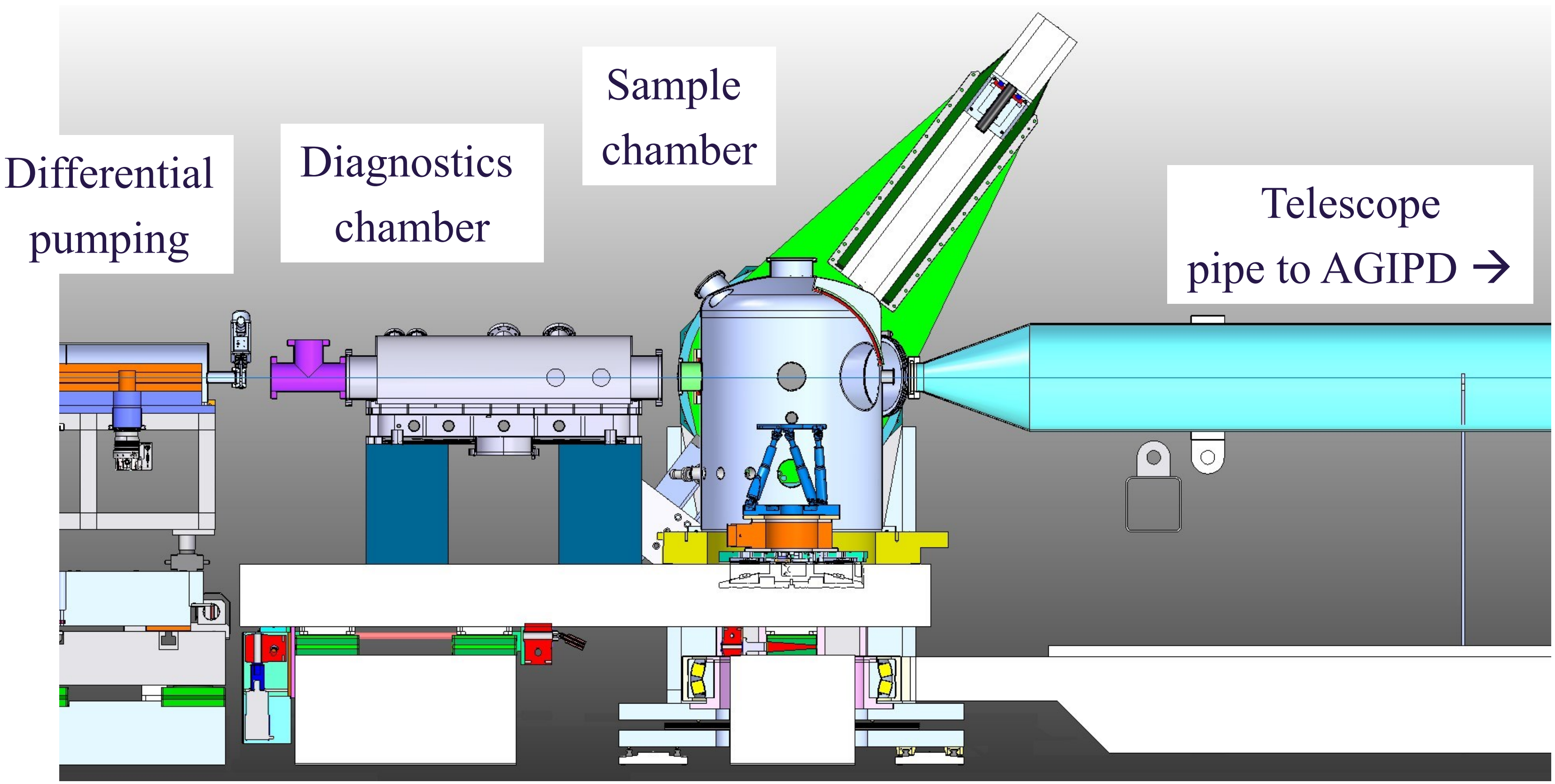
Experimental Setup



Hi-Res setup: AGIPD up to 8 m from sample chamber.

Telescope pipe between chamber and AGIPD. Motion concept under study

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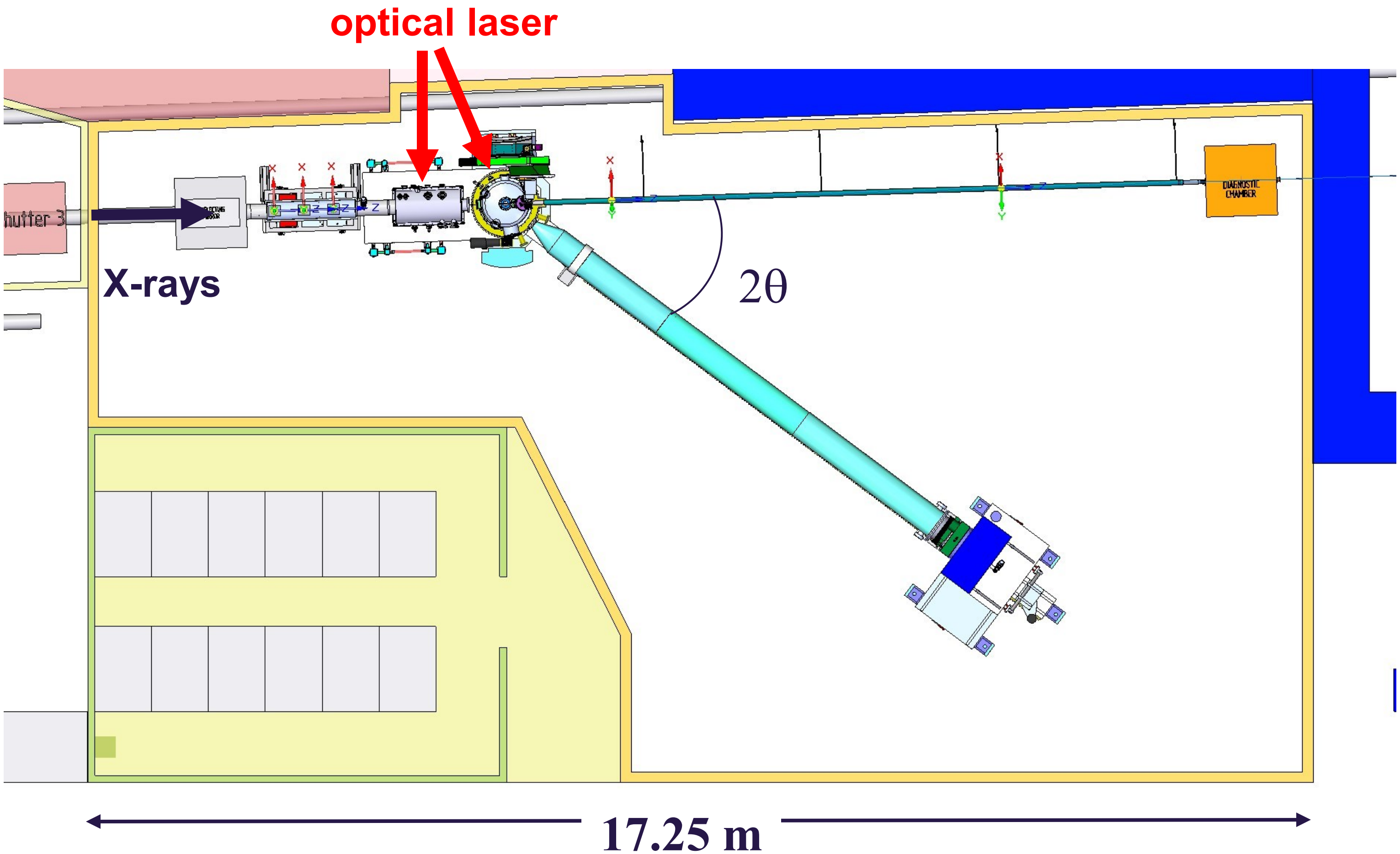
Experimental Setup



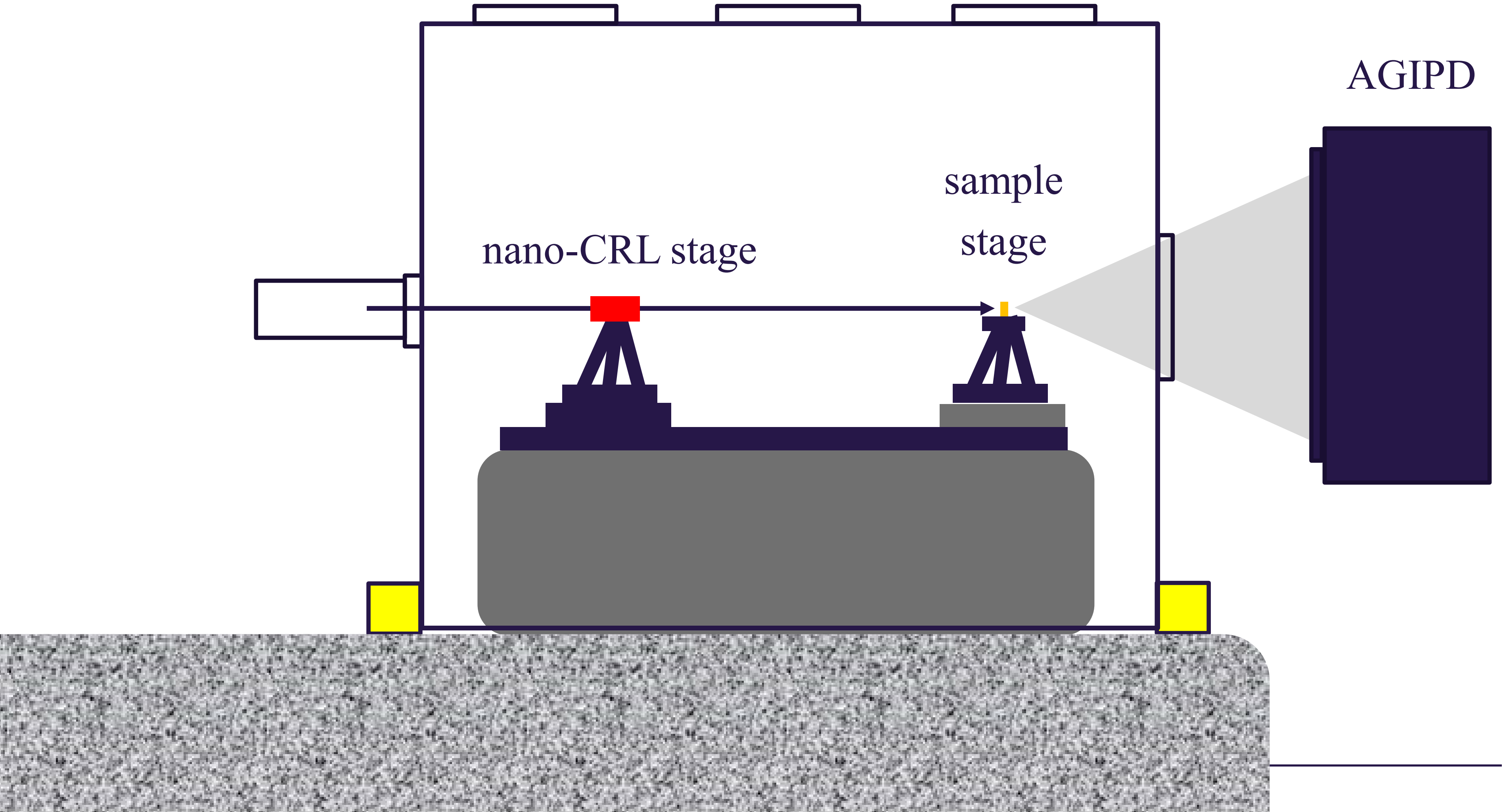
2θ up to ~60 deg in Hi-Res mode.

Diagnostics end-station (spectrum, intensity, position) and beam stop

Experimental chamber

Min. dist. sample-detector: ~225 mm

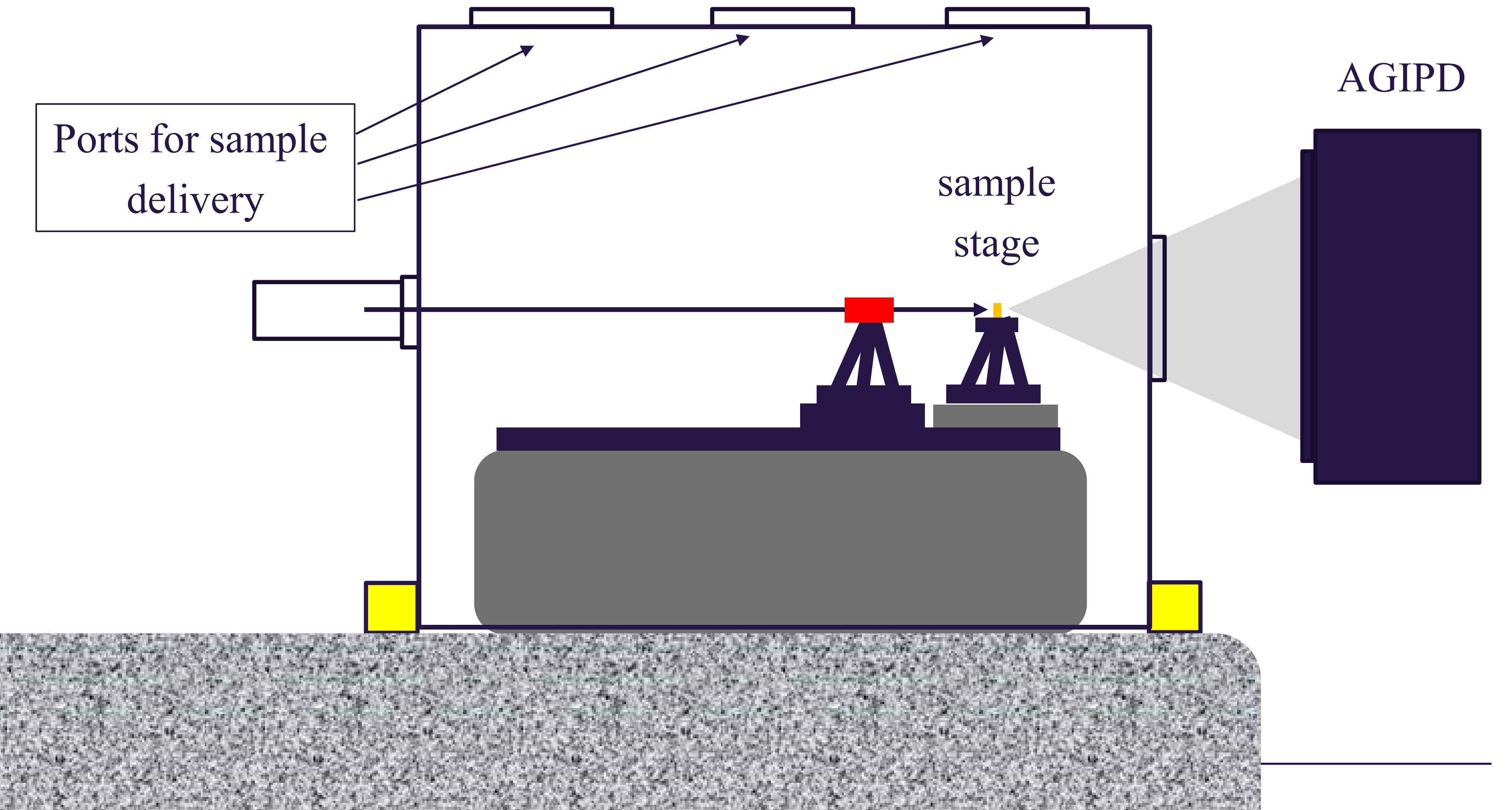
Q_{max} ~5Å^{-1} (λ=1Å)



Experimental chamber

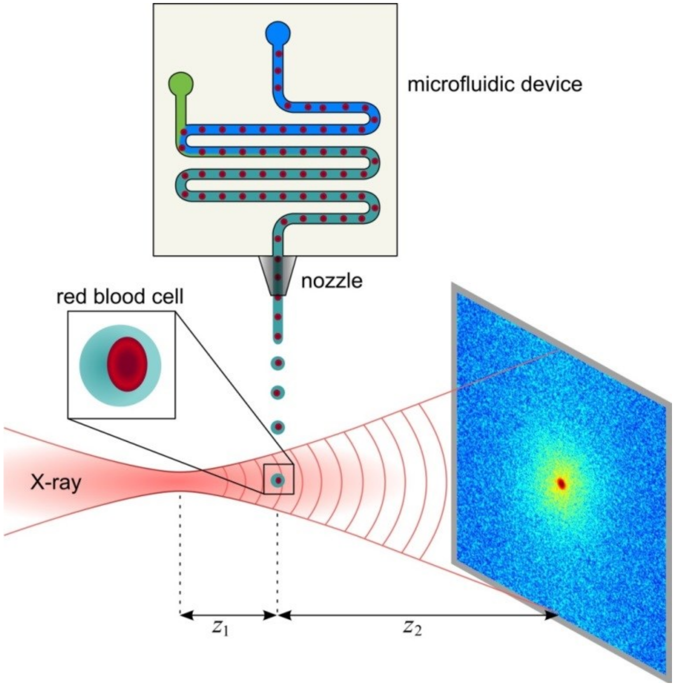
Min. dist. CRL-sample: 50 mm

Min. focal spot: ~10 nm (ideal case)



Sample delivery

Microfluidic sample delivery



Full-field microscope:
S. Köster & T. Salditt
Univ. Göttingen (BMBF project)

10 Hz sample changer/scanner for solid samples

Flexible mount (hexapod) for user's sample environments

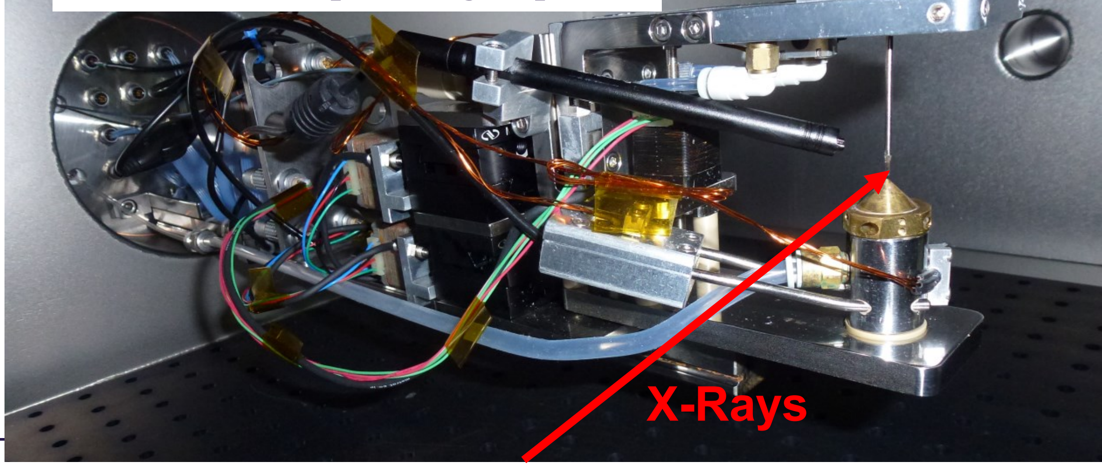
Pulsed high B magnet

Aerosol injector, liquid jet

Furnace, cryostat

Possibility to work in air (window inserted upstream)

liquid jet installed in test chamber (XFEL sample env. group)



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Hard X-Ray Split-Delay Line

Goal: To modify the time-structure of XFEL (fs-ps delays). Spatial offset (inclination) between split beams can be introduced. New possibilities for time-resolved experiments (PP, wave mixing, holography, speckle, dynamics,..).

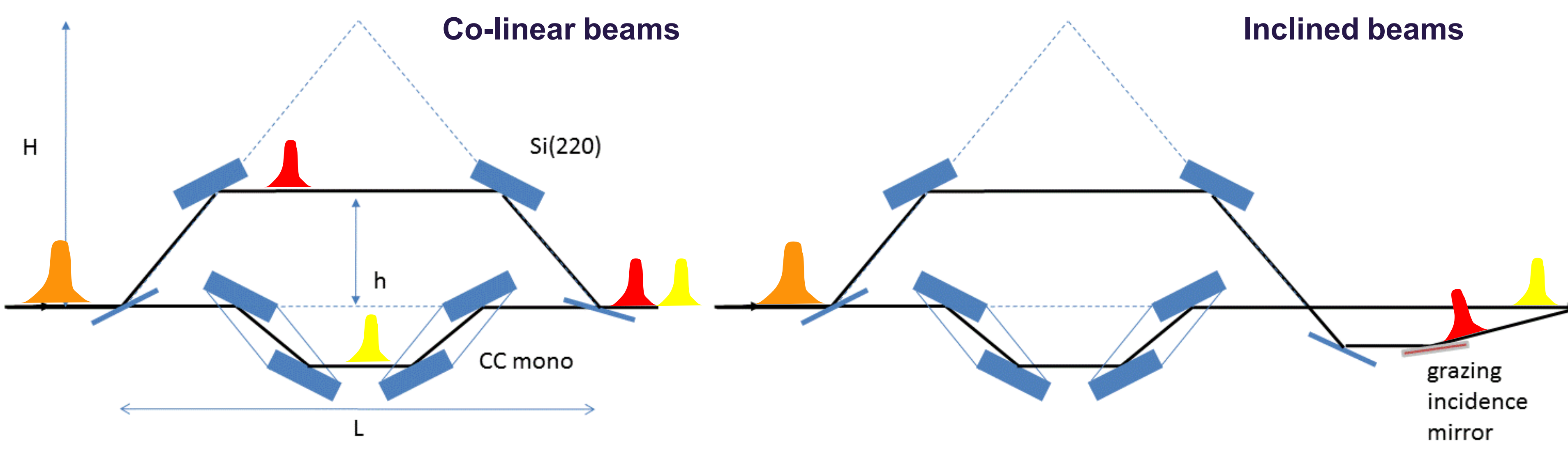
Inspiration:

Hard X-ray Split Delay line at LCLS (Roseker & Grübel, DESY)

Device under construction at SACLA (Tono, Yabashi, SACLA)

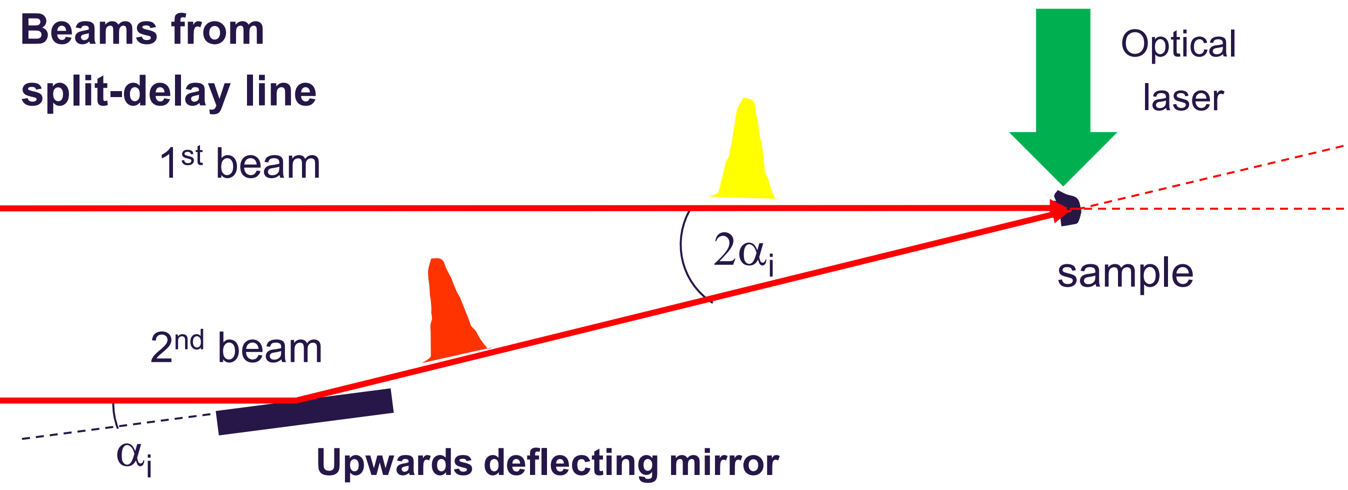
1μm → 3.3 fs

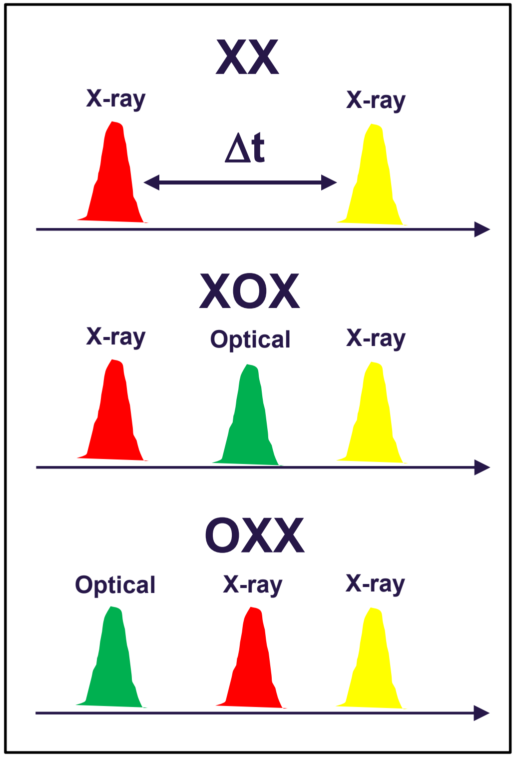
Soft X-ray delay lines operating at FLASH (mirror based)



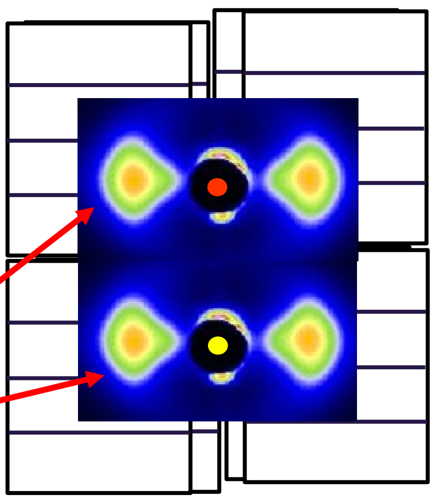
Hard X-Ray Split-Delay Line

Beams from split-delay line





Two images on detector:



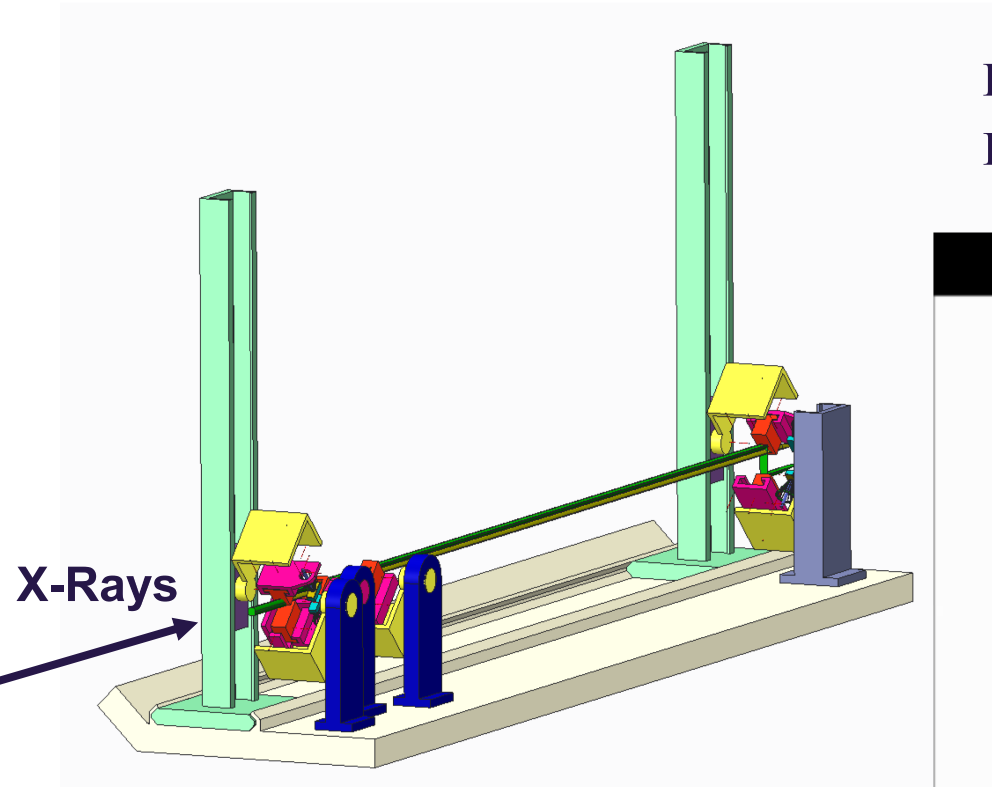
2^{nd} pattern

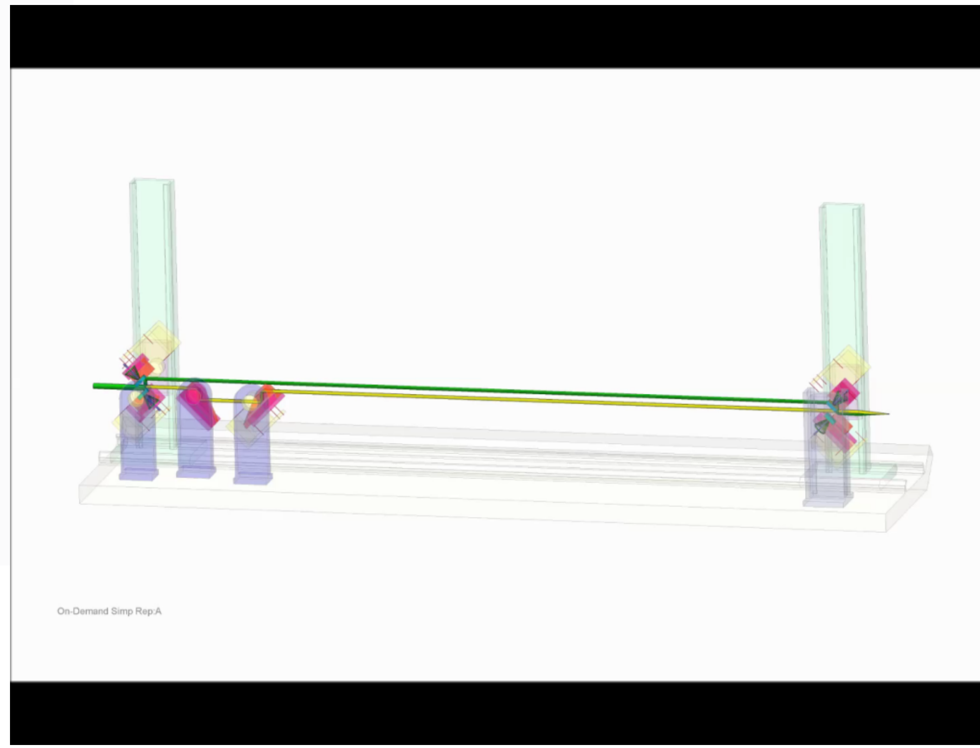
1^{st} pattern

Hard X-Ray Split-Delay Line

Delay given by upper branch (0 – 800 ps)

Energy tunable (5 - 10 keV)





In-vacuum setup

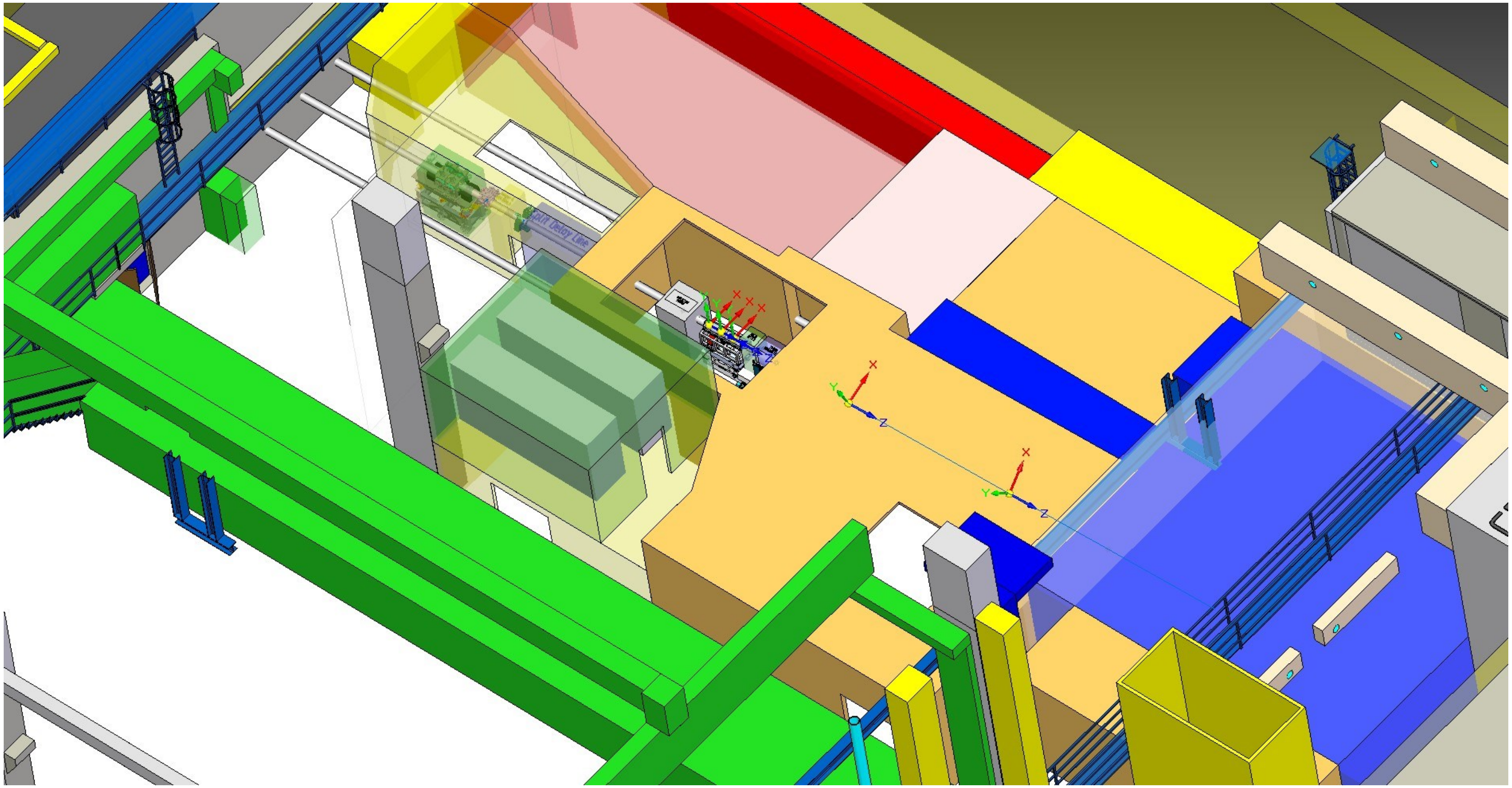
High position precision and stability

Laser interferometry to control delay

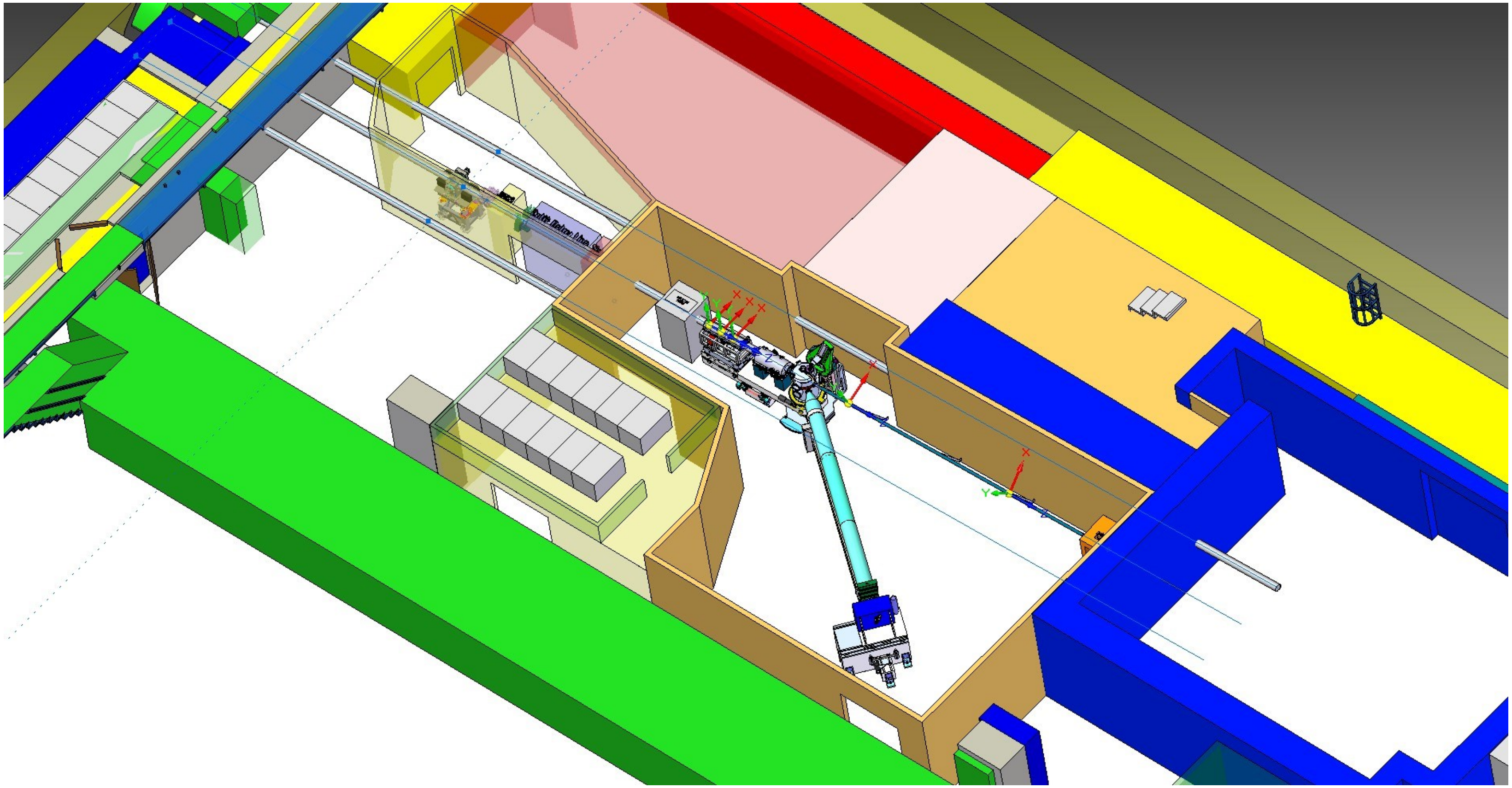
Beam diagnostics

Collaboration: S. Eisebitt, T. Noll, TU Berlin (BMBF project)

SASE-2: Hutches and Infrastructure



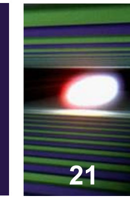
SASE-2: Hutches and Infrastructure



Work in progress…

European XFEL

MID Technical Design Report (TDR)



European XFEL - Documents - Technical Reports & Notes - Mozilla Firefox

File Edit View History Bookmarks Tools Help

European XFEL - Documents - Technical...

www.xfel.eu/documents/technical_documents/

- Technical Design Report: Scientific Instrument SQS
  December 2012, XFEL.EU TR-2012-007, doi:10.3204/XFEL.EU/TR-2012-007
- Technical Design Report: Scientific Instrument FXE
  December 2012, XFEL.EU TN-2012-008, doi:10.3204/XFEL.EU/TR-2012-008
- Conceptual Design Report: Undulator Control Systems
  January 2013, XFEL.EU TR-2013-001, doi:10.3204/XFEL.EU/TR-2013-001
- Conceptual Design Report: Scientific Instrument HED
  May 2013, XFEL.EU TN-2013-003, doi:10.3204/XFEL.EU/TR-2013-003
- Detector Geometries for Coherent X-Ray Diffractive Imaging at the SPB Instrument
  August 2013, XFEL.EU TR-2013-007, doi:10.3204/XFEL.EU/TR-2013-007
- Technical Design Report: Scientific Instrument Single Particles, Clusters, and Biomolecules (SPB)
  August 2013, XFEL.EU TR-2013-004, doi:10.3204/XFEL.EU/TR-2013-004
- Technical Design Report: Scientific Instrument MID
  October 2013, XFEL.EU TR-2013-005, doi:10.3204/XFEL.EU/TR-2013-005
- Conceptual Design Report: Scientific Instrument Spectroscopy and Coherent Scattering (SCS)
  November 2013, XFEL.EU TR-2013-006, doi:10.3204/XFEL.EU/TR-2013-006
- Estimates of the Fluorescence-Induced Backscattered Dose for the LPD Detector
  December 2013, XFEL.EU TR-2013-002, doi:10.3204/XFEL.EU/TR-2013-002

Technical Notes

- XFEL-3D-Coordinates, first phase design
  December 2007, XFEL.EU TN-2007-001

XFEL.EU TR-2013-005

TECHNICAL DESIGN REPORT

Scientific Instrument Materials Imaging and Dynamics (MID)

October 2013

A. Madsen, J. Hallmann, T. Roth, and G. Ansaldi for the Scientific Instrument MID (WP83) at European XFEL

European X-Ray Free-Electron Laser Facility GmbH
Albert-Einstein-Ring 19
22761 Hamburg
Germany

European XFEL

http://www.xfel.eu/documents/technical_documents/

or

https://bib-pubdb1.desy.de/record/154260

Poster #108, Friday poster session

Main specs of MID (from TDR)

Photon energy range	5–25 keV (coherent) and > 25 keV (high-energy option)
Bunch charge	1–1000 pC
Polarization	Linear (horizontal)
Pulse duration	1–100 fs
Beam size on the sample	1–200 µm, 1 mm, and nanofocus option
Beamline optics	2 monochromators (Si(111) and Si(220)) 2 compound refractive lens (CRL) transfocator units Split and delay line High-energy Laue monochromator (optional)
Equipment	Multipurpose chamber, SAXS/WAXS geometries with long horizontal detector arm, small vertical WAXS setup, single-pulse X-ray diagnostics, different detector systems (AGIPD, FastCCD), optical pump laser source

Commissioning and first user experiments in 2017!