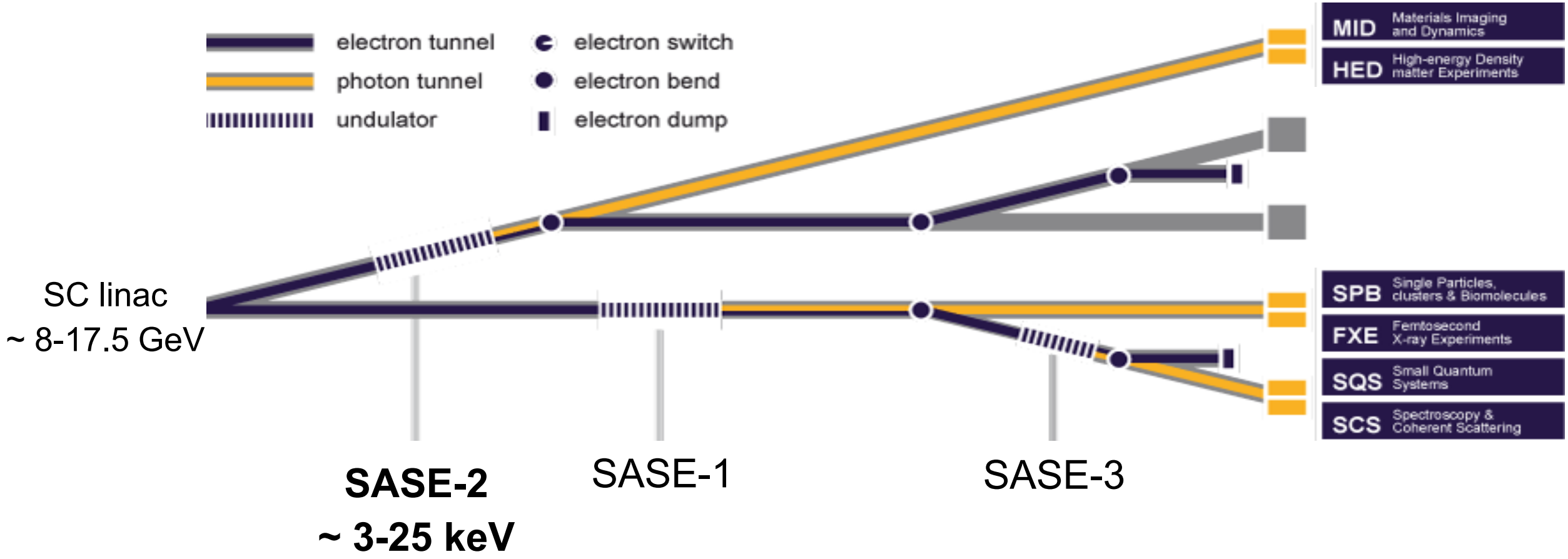
Status SASE-2:
The HED and MID experiments at European XFEL

A. Madsen & U. Zastrau

European XFEL User Meeting, January 2018

Facility outline



12/12h operation of instruments on every beamline (distribution mirrors)

SASE-2 undulator

- SASE-2 undulator >95% installed (35 x 5 m segments) NdFeB magnets, period 40 mm
- Jan 2018: Mechanical comm.
- Installation of dose monitor and air coil correctors
- Ready for beam: March 2018
- 1st lasing attempt: April 2018?

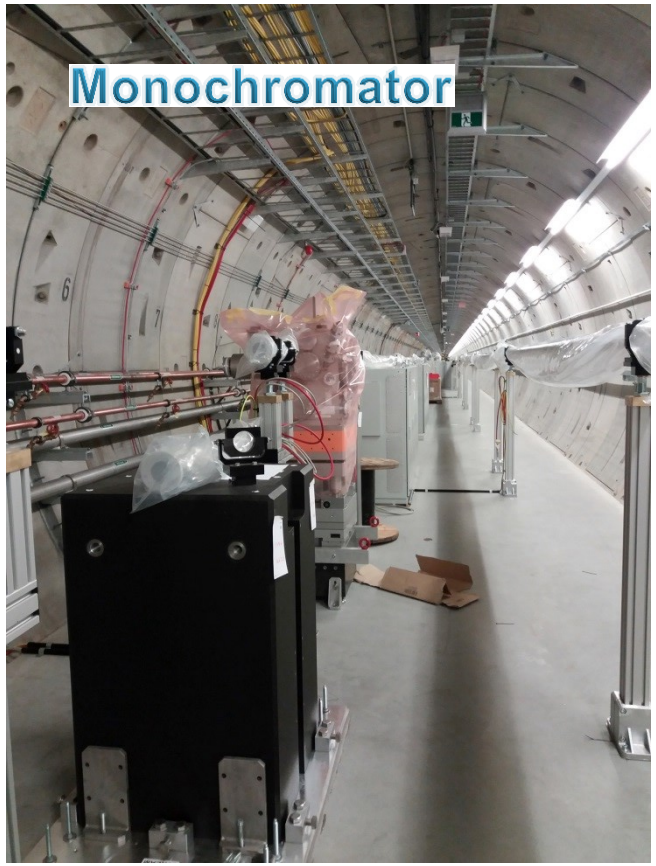
The SASE-2 undulator located behind protection panels for better AC control
Photo: View from segment 27 and downstream (credit: J. Pflueger and XFEL undulator group)

SASE-2 tunnel installation status WP73

- All components are delivered and installed
- Survey of components 60% completed (XTD1 complete, XTD6 ongoing)
- Establishing of complete vacuum system is ongoing (currently about 10% under vacuum)
- All electronic racks are installed and connected, local cabling ongoing (40% complete).
- All safety relevant components (shutters&shieldings) were approved by TÜV.
- Optics: Beam transport mirrors were received and characterized in Metrology lab. Coating is ongoing (B4C +Pt). Optics will be mounted, as soon as overall system (vacuum, controls) allow save operation.
- Major challenges are electronics installations, cabeling, and software development and debugging (Beckhoff and Karabo).
- First lasing, start of commissioning with beam in tunnel in May

Slide from Harald Sinn
XFEL optics group

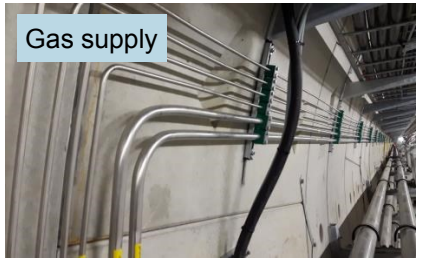
SASE-2 tunnel installation status WP73

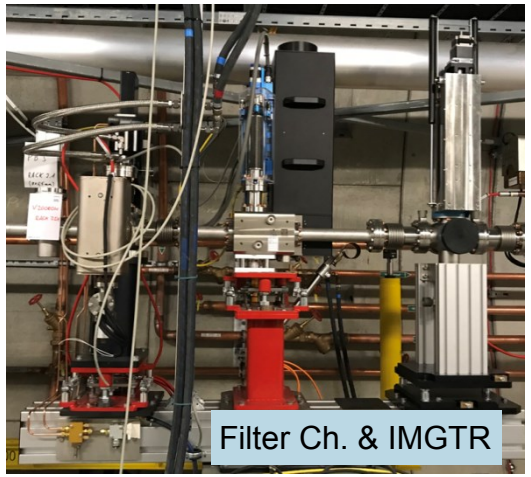


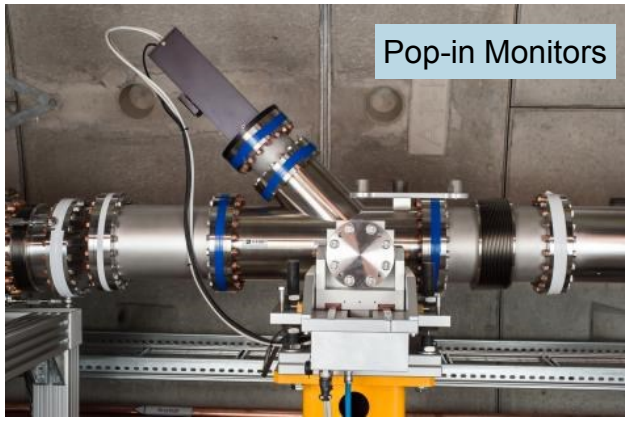
Slide from Harald Sinn
XFEL optics group

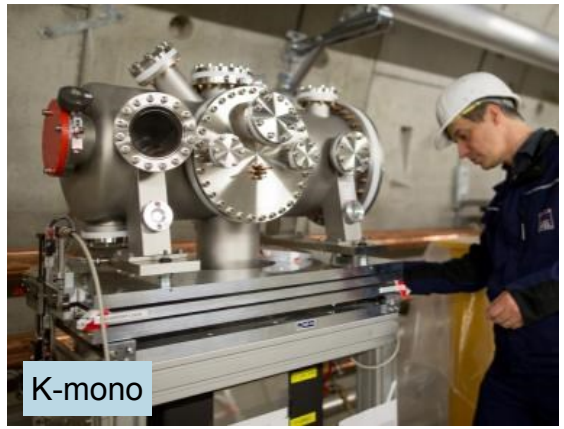
Status photon diagnostics

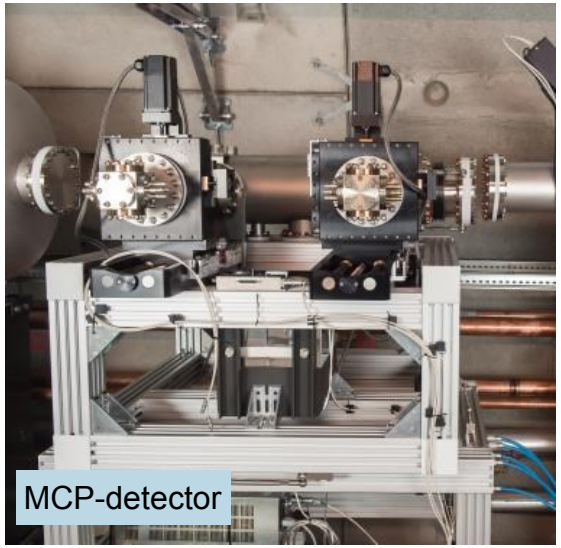
- all SASE2 diagnostics vacuum systems are in the tunnel







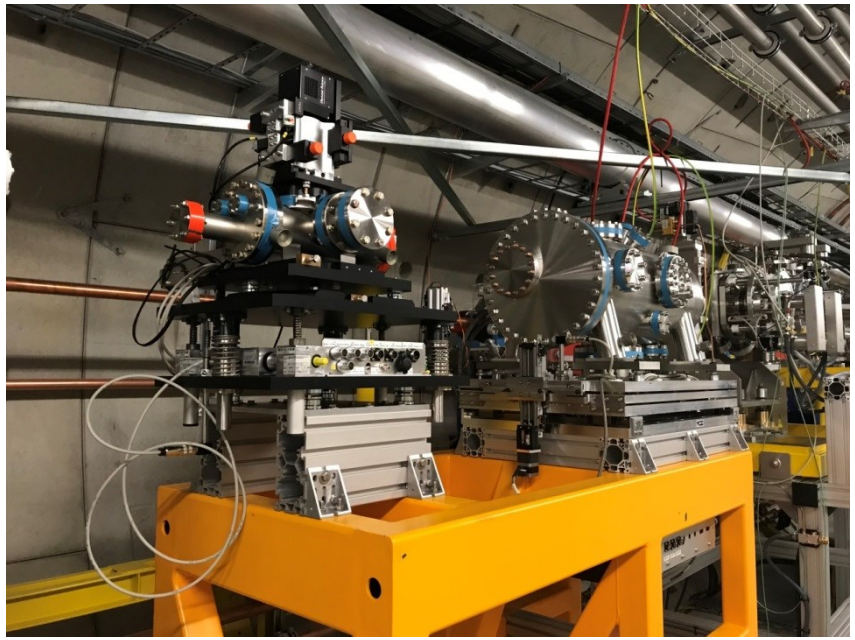




Acknowledgement: Jan Grünert and the photon diagnostics group

Status photon diagnostics

- KMONO and SR imager installed on common frame
- Next: connection to beamline vacuum



- XGM in XTD1 (common for MID and HED)
- Vacuum operating (stand-alone)
- DOOCS control established

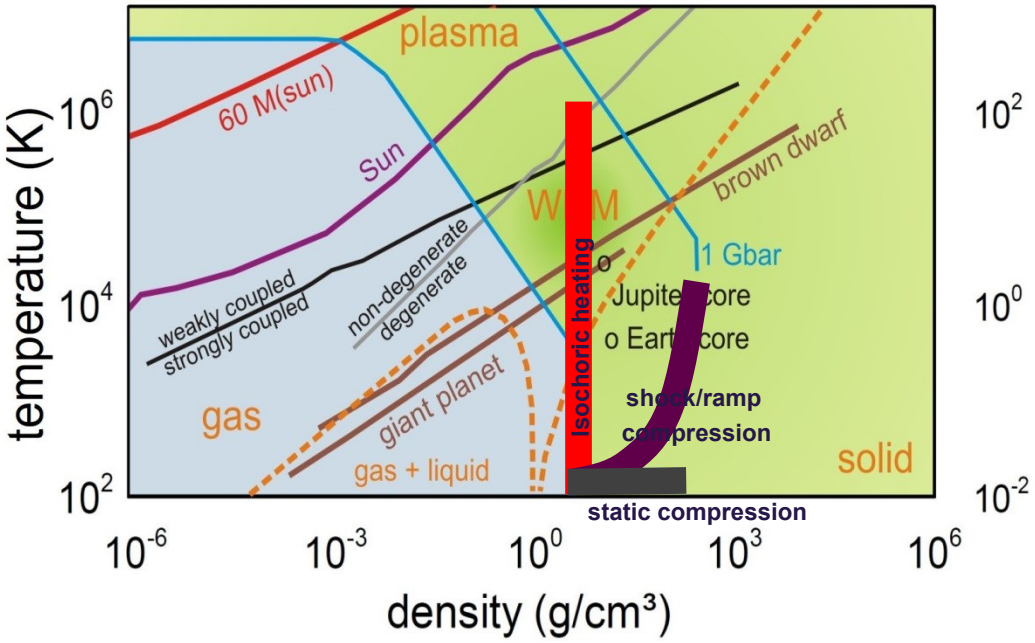
Slide adapted from Jan Grünert

SASE-2 instrument HED: High Energy Density

Exploring High Energy Density matter with x-ray lasers

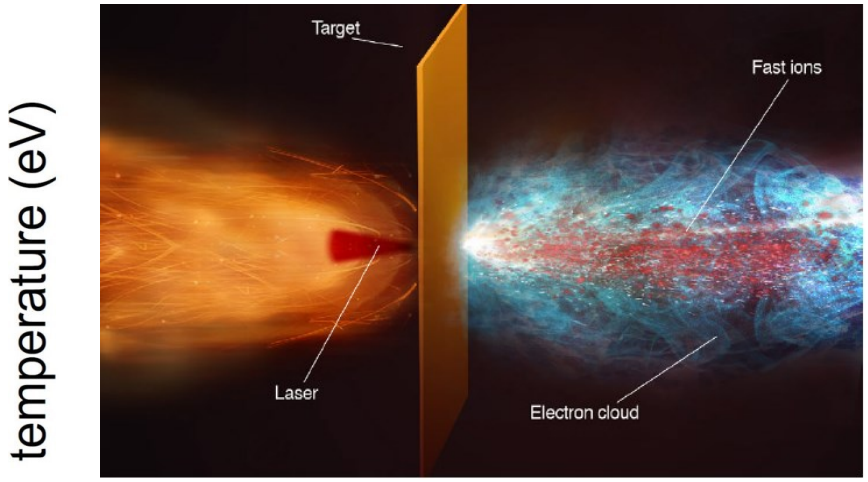
Warm and hot dense matter regime

- Determine EOS
- Measure structural phase transitions
- Mixing and demixing properties
- Non-equilibrium processes
- ...



Relativistic laser plasmas

- Plasma instabilities
- Electromagnetic field dynamics
- Secondary beam diagnostics (protons)
- …

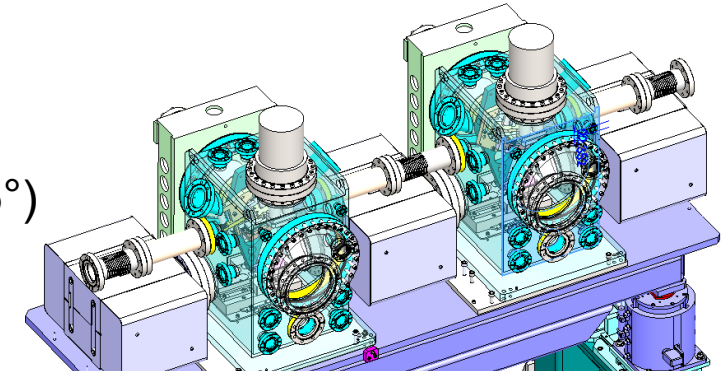


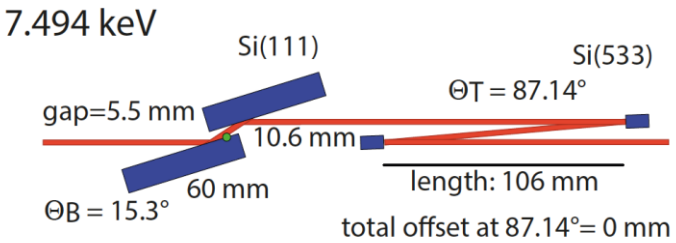
from A. Macchi et al.,
Rev. Mod. Physics (2013)

HED specific tunnel components

Fixed exit 4-bounce monochromator

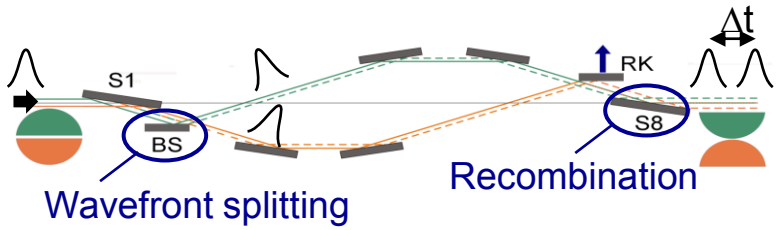
- Energy range: 5 - 25 keV (24.5° - 4.5°)
- Cryogenically cooled
- $\Delta E/E = 10^{-4}$: Si_{111} monochromator





Second high-resolution mono stage

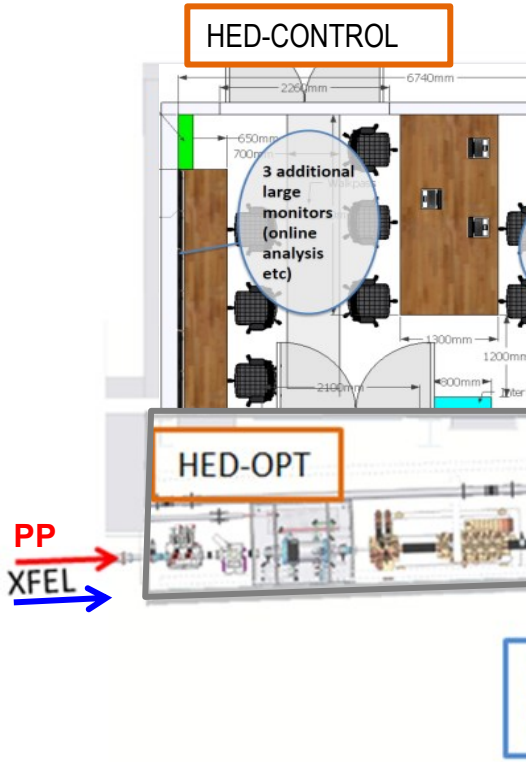
- $\Delta E/E = 10^{-6}$: Si_{533} ➔ 7.494 keV

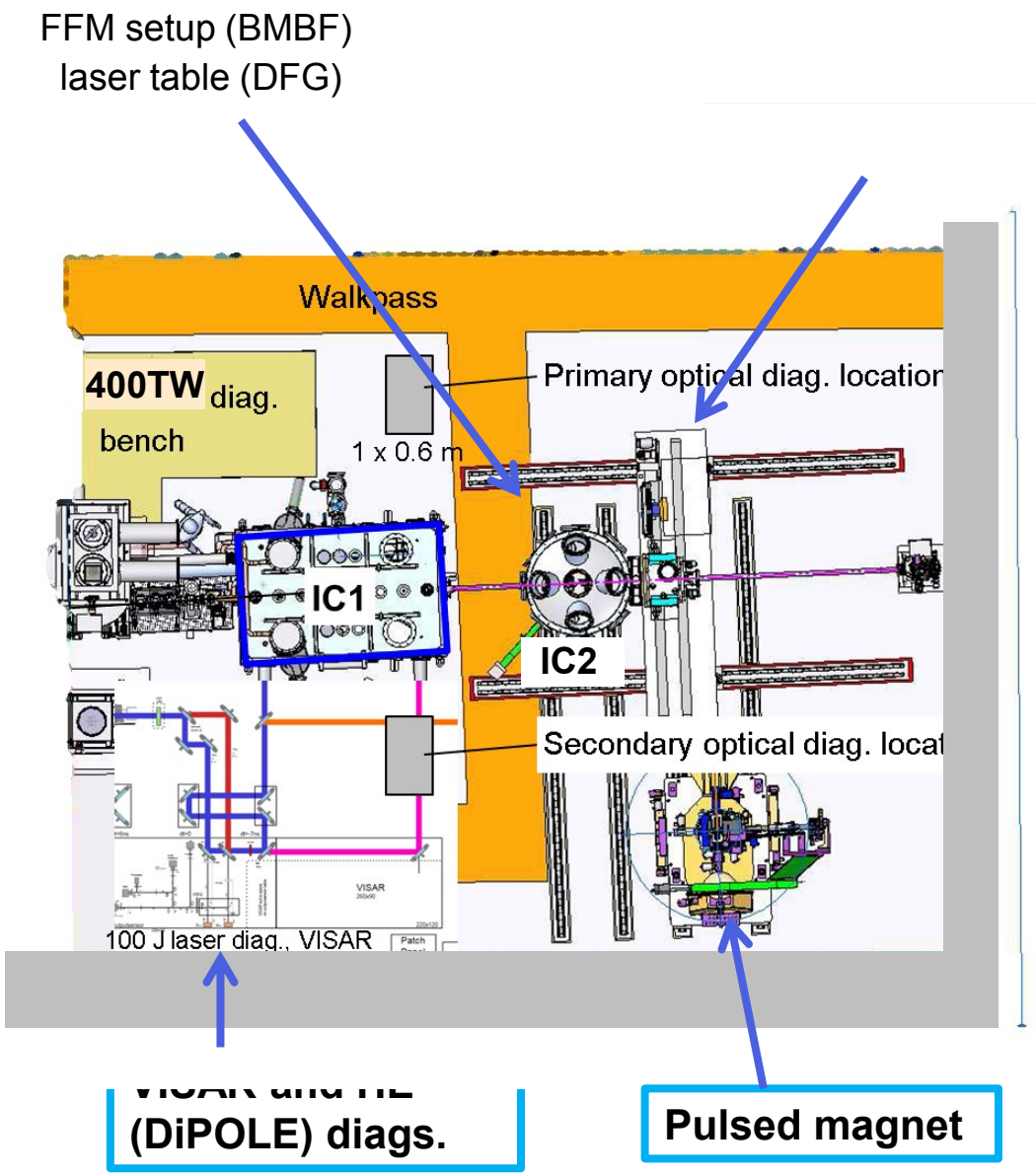


Split-and-Delay Line (BMBF 05K10PM2)

- Multi-layer mirrors
- Variable delay up to
  23 ps (5 keV), 2 ps (20 keV)
- Build by Univ. Münster

HED hutch overview





Installation of IC1 (May 2017)

Unique capabilities arise when:

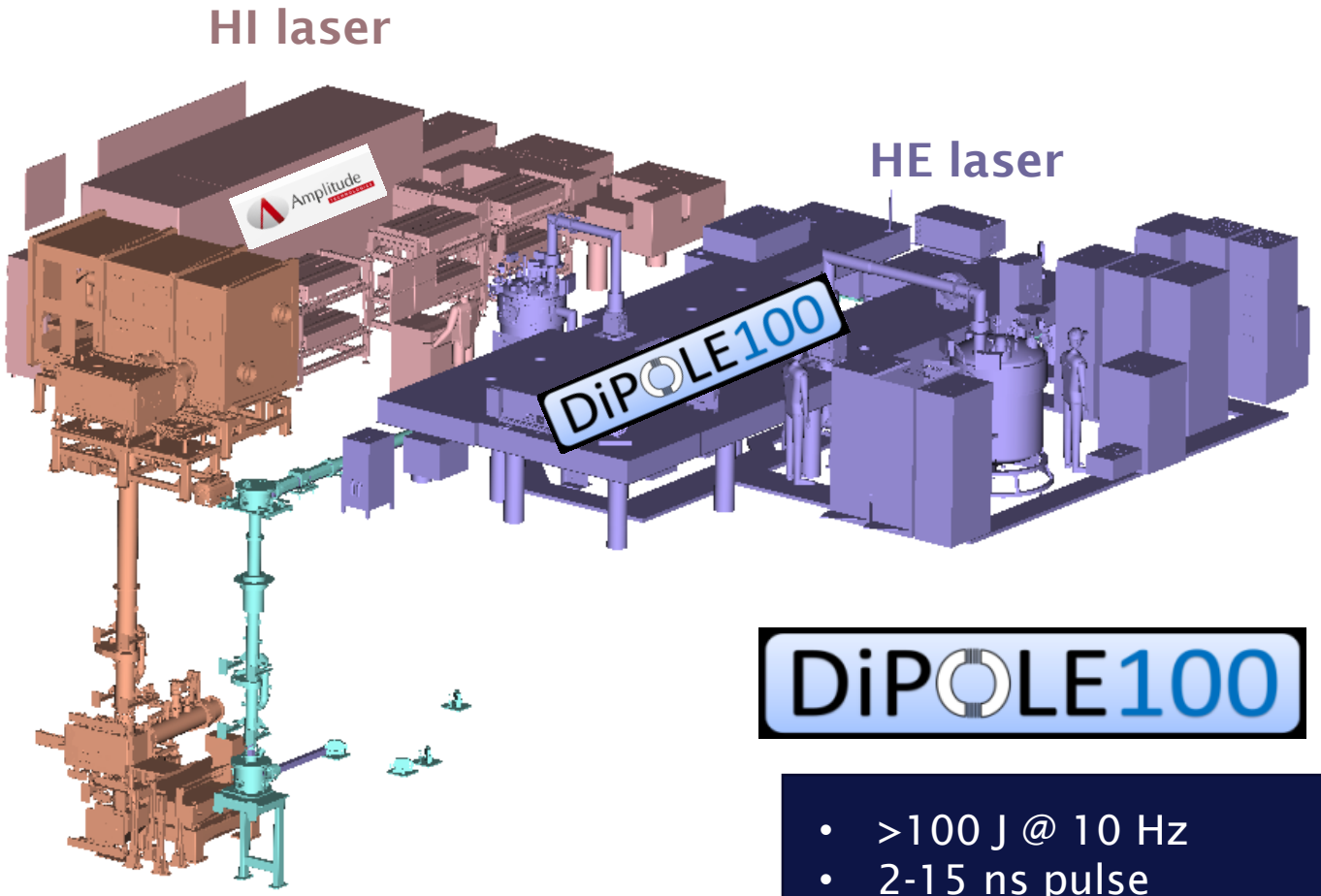
XFEL beam is coupled to powerful drivers

- Powerful optical lasers (HiBEF consortium)
  100 J 15 ns 10 Hz (High Energy) 200 TW 30 fs 10 Hz (High Intensity)
- Diamond Anvil Cells (HiBEF consortium)
  dynamic DAC; pulsed laser heated DAC; double-stage DAC)
- XFEL split & delay line, mirror based (x-ray pump-probe), BMBF Univ. Münster
- Up to 60 T pulsed magnetic field coil (HiBEF consortium)

HED lasers on top of experimental hutch

Amplitude TECHNOLOGIES

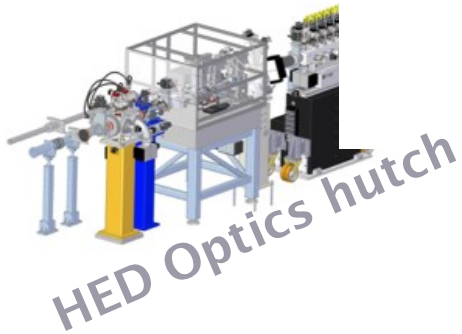
- >100TW @ 10 Hz
- >300 TW @ 5 Hz
- double CPA Ti:Sa
- shot on demand
- high redundancy
- delivery Q2 2018



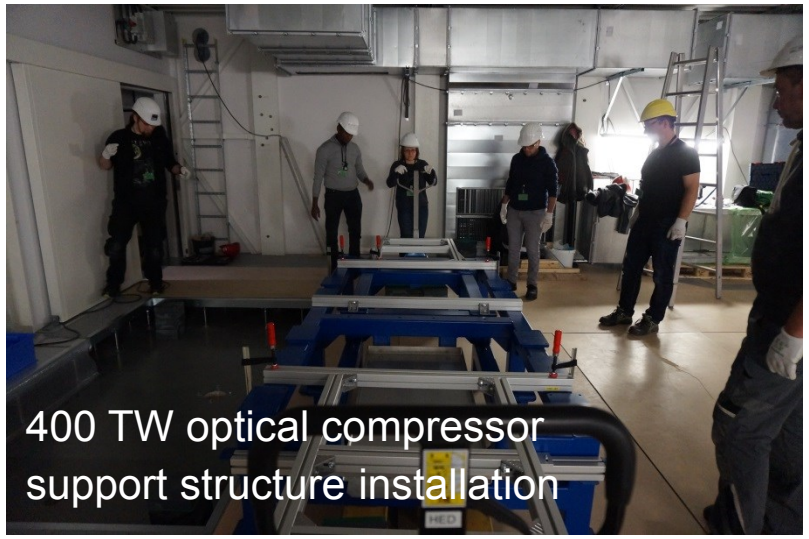
DiPOLE100

- >100 J @ 10 Hz
- 2-15 ns pulse
- pulse shaping
- 2ω conversion
- delivery mid 2018

Lasers provided by
HiBEF user consortium



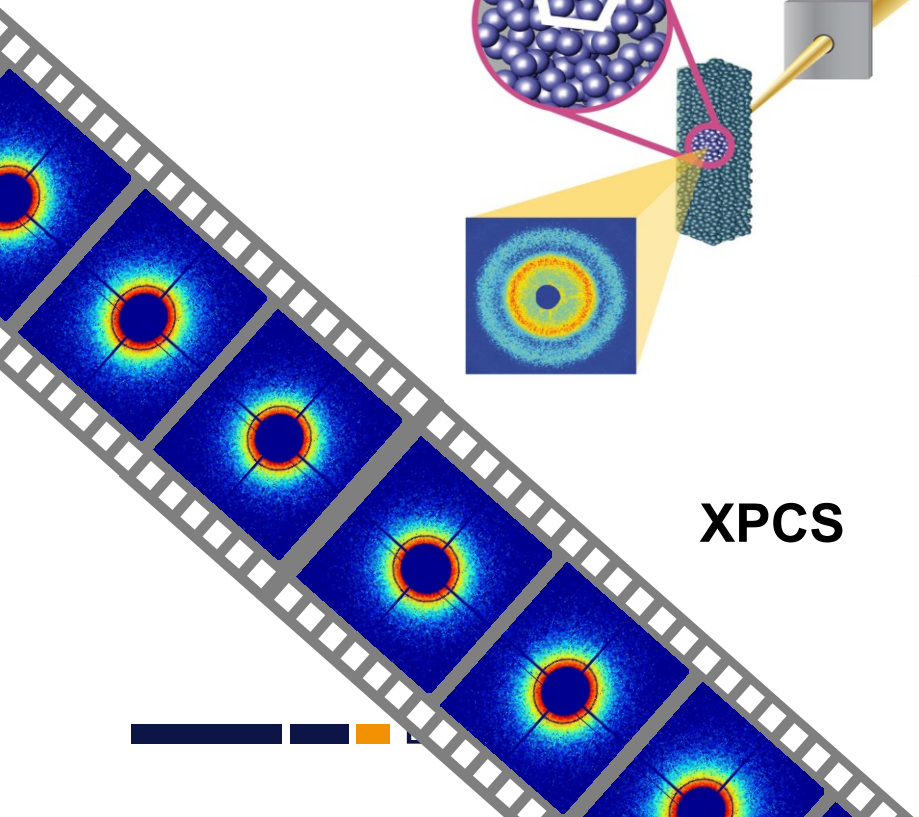
Progress in the HiBEF laser bay (on top of EXP hutch)



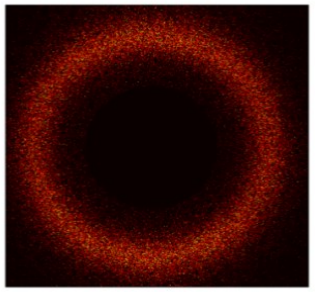
SASE-2 instrument MID: Materials Imaging and Dynamics

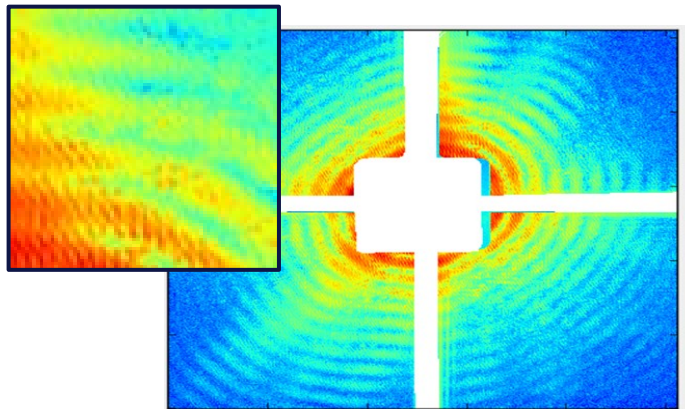
The Materials Imaging and Dynamics (MID) station aims at the investigation of nanosized **structure** and nanoscale **dynamics** using **coherent hard X-rays**. Applications to a **wide range of materials** from hard to soft condensed matter and biological structures are envisaged

(1st MID workshop, Oct 2009 @ ESRF, Grenoble)

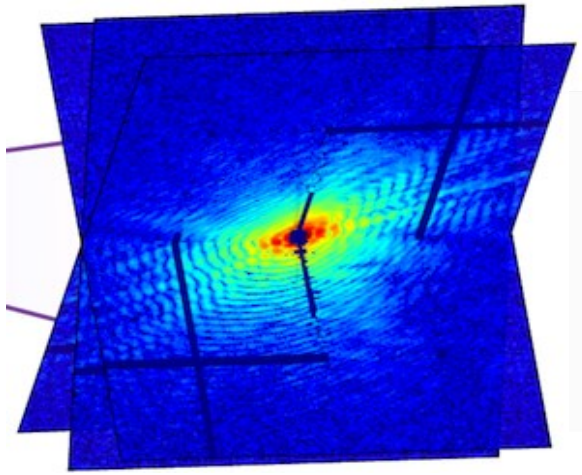


XCCA

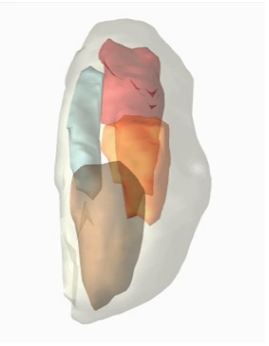




CDI



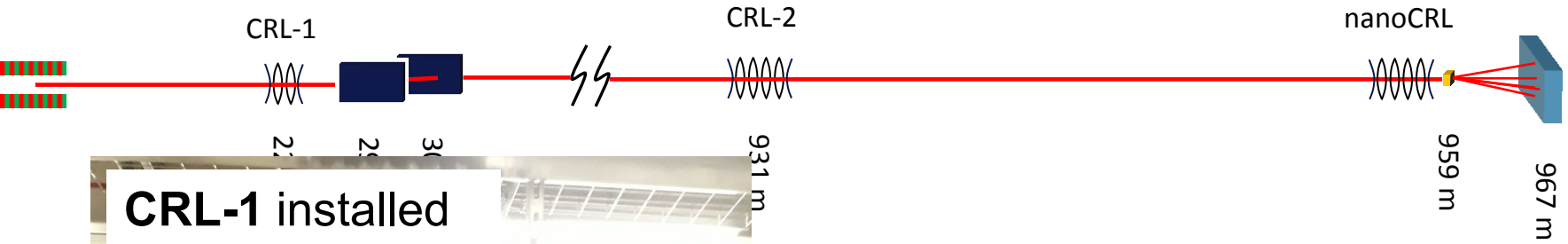
Holography

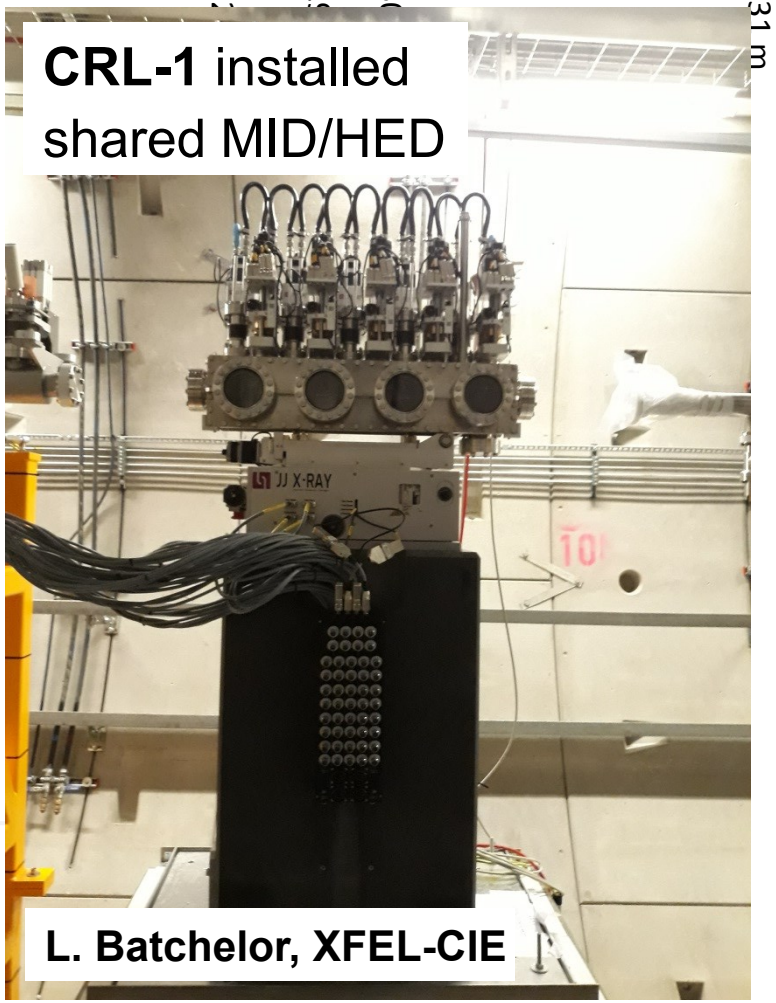


XPCS

in combination with:
- Pump-probe
- Spectroscopy
- Nano-focusing
- Split-delay techniques

MID focusing scheme





CRL-1 installed shared MID/HED

L. Batchelor, XFEL-CIE

CRL-1 collimation

simple CRL-1 focusing

combined CRL-1&2 focusing

focusing via intermediate focus

collimate, then focus

brute CRL-2 focusing

Beam size on sample ~ 2-1000 µm

Eff. >80% for most schemes and energies

Nanofocusing option

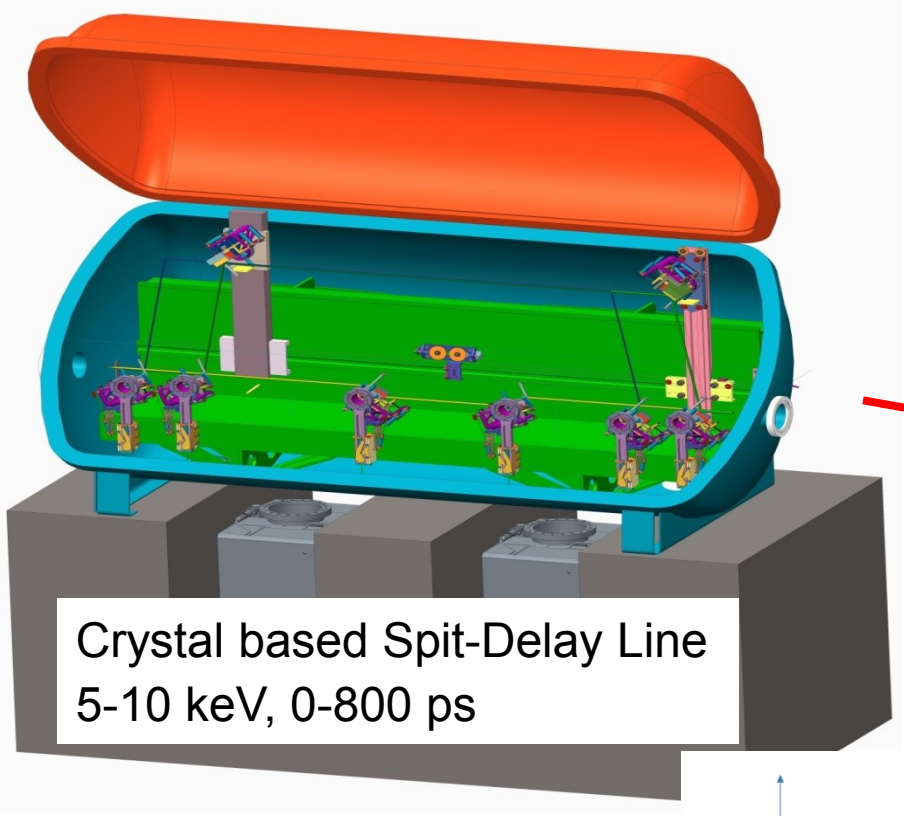
Energy	Beam size (FWHM)
5 keV	187 nm
8 keV	117 nm
12 keV	78 nm
16 keV	58 nm
25 keV	37 nm

Calculation for f = 300 mm

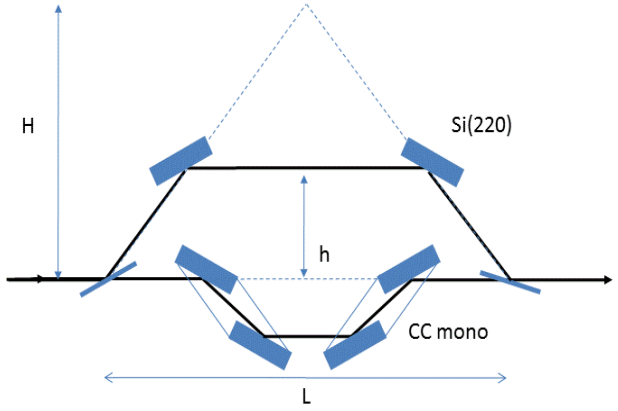
Efficiency ~50% with pre-focusing

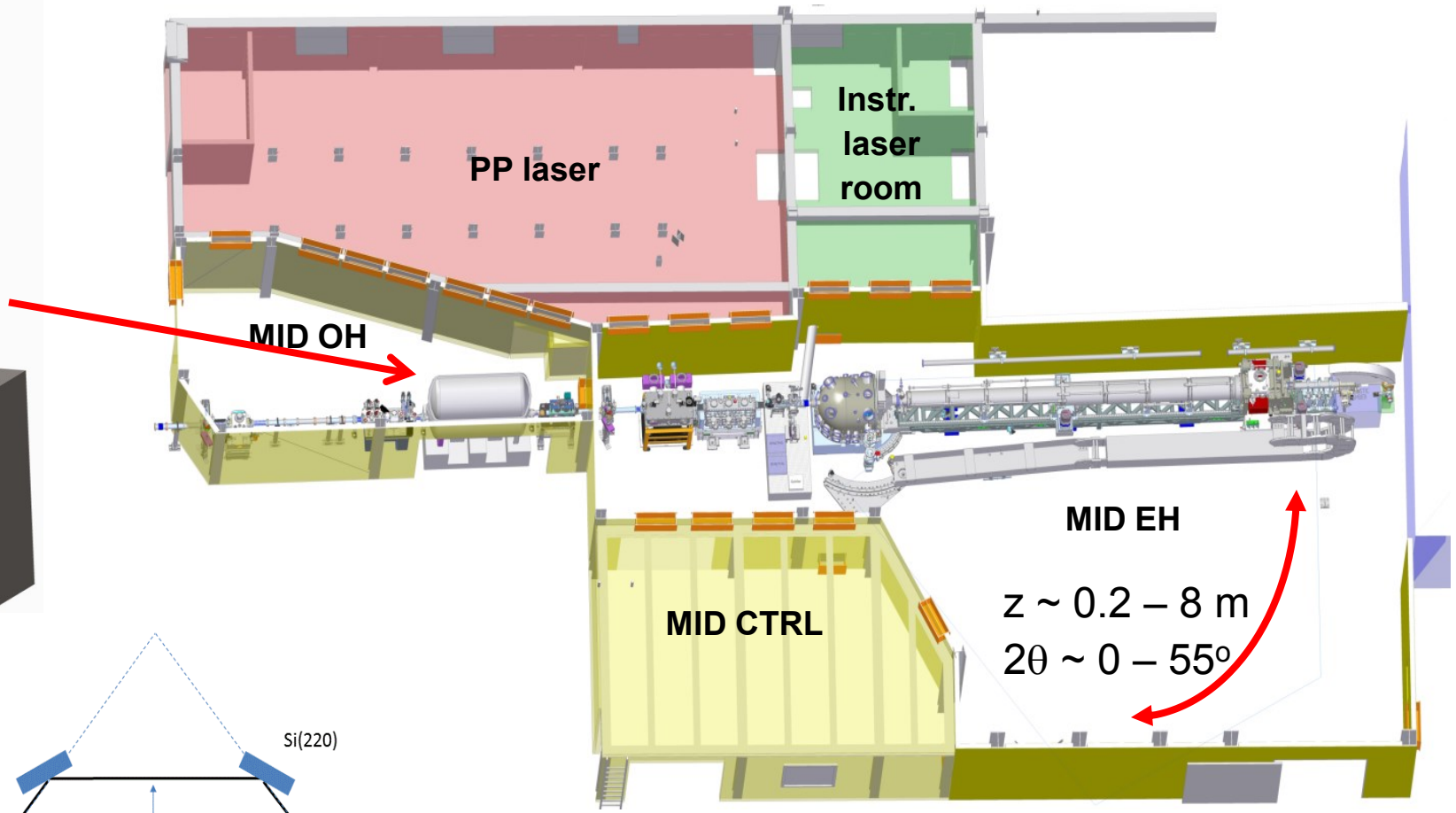
~10 nm focus for f = 50 mm at 12 keV

MID hutches overview

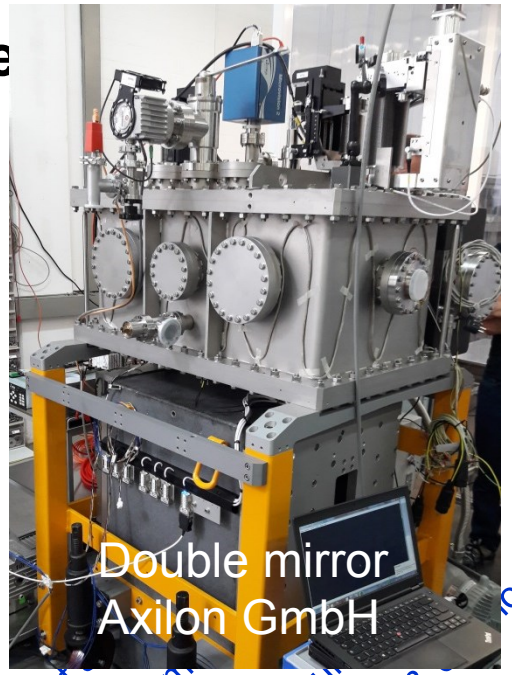


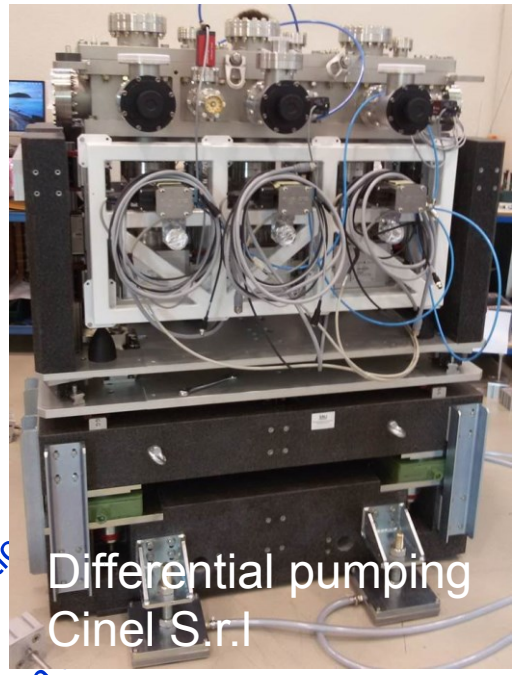
BMBF Project,
Eisebitt group, MBI Berlin

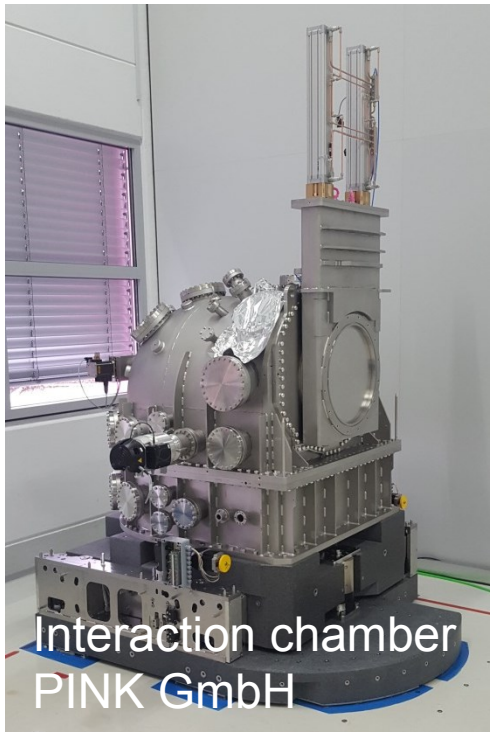


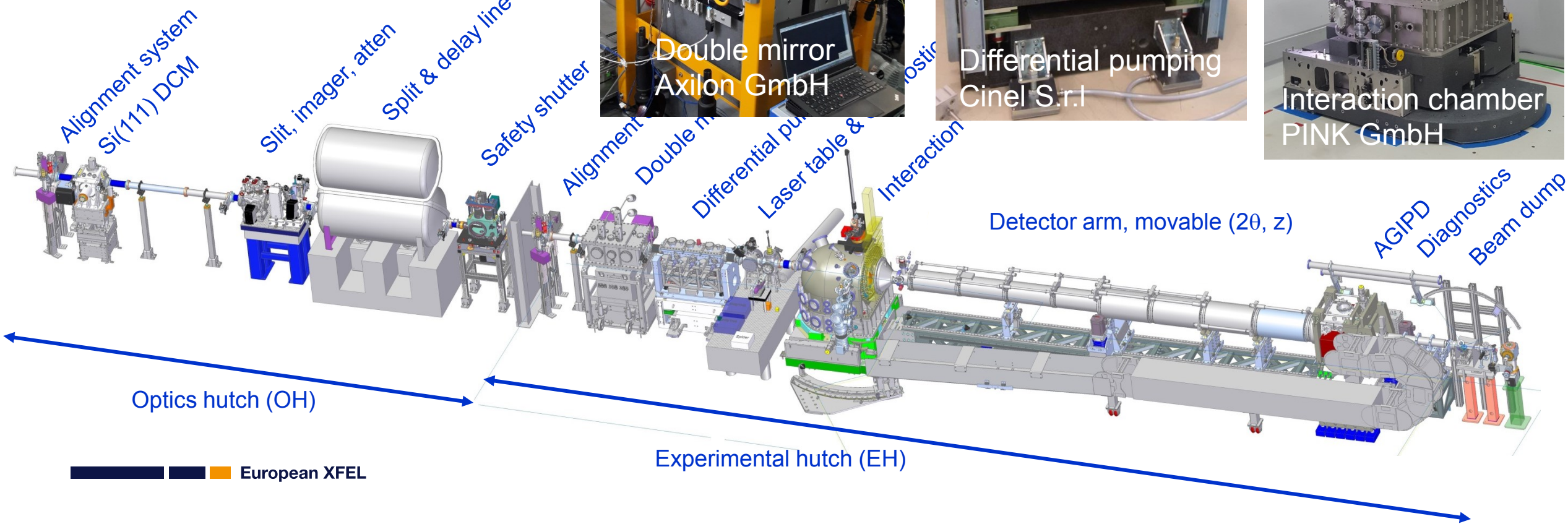


General layout of MID instrume









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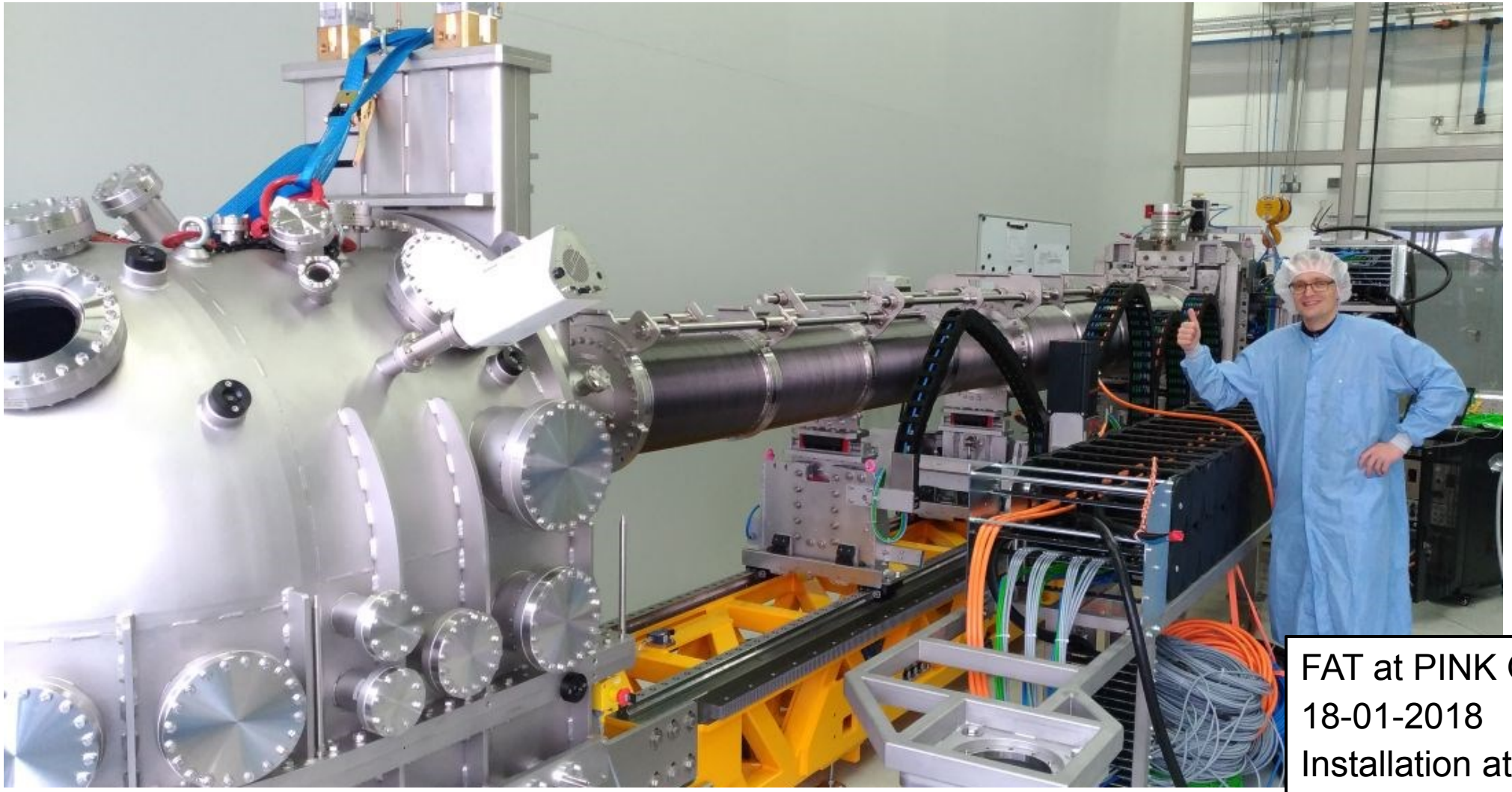
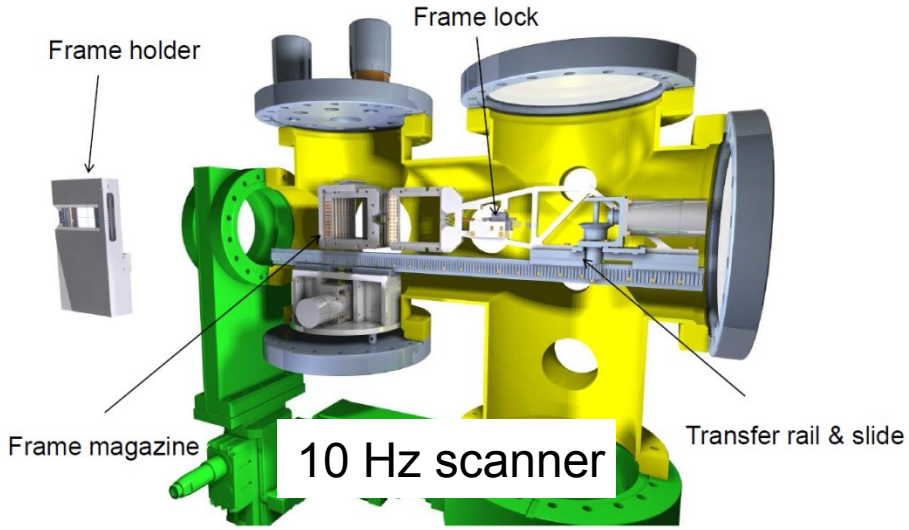
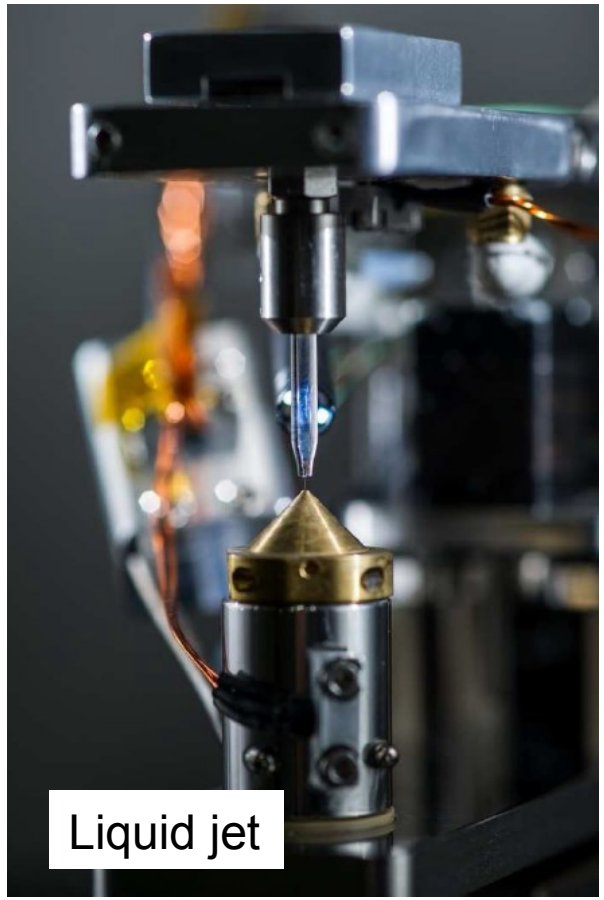


FAT at PINK GmbH:
18-01-2018
Installation at MID:
Feb – Mar

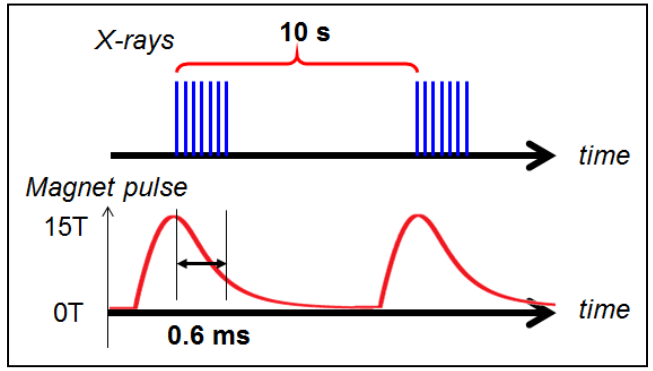
Sample environments at MID

- Hexapod, goinometer
- Liquid jet, cryo jet
- Pulsed B-field
- 10 Hz sample scanner
- Polarimetry setup
- SAXS-WAXS-large field of view

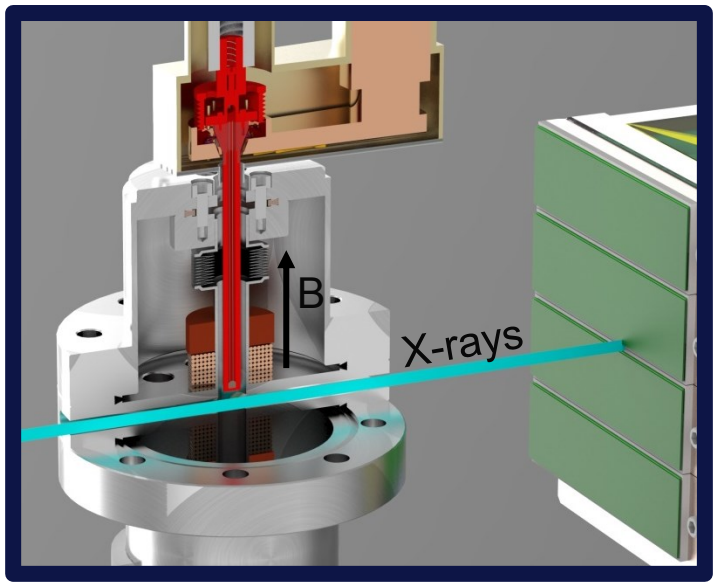




Pulse timing



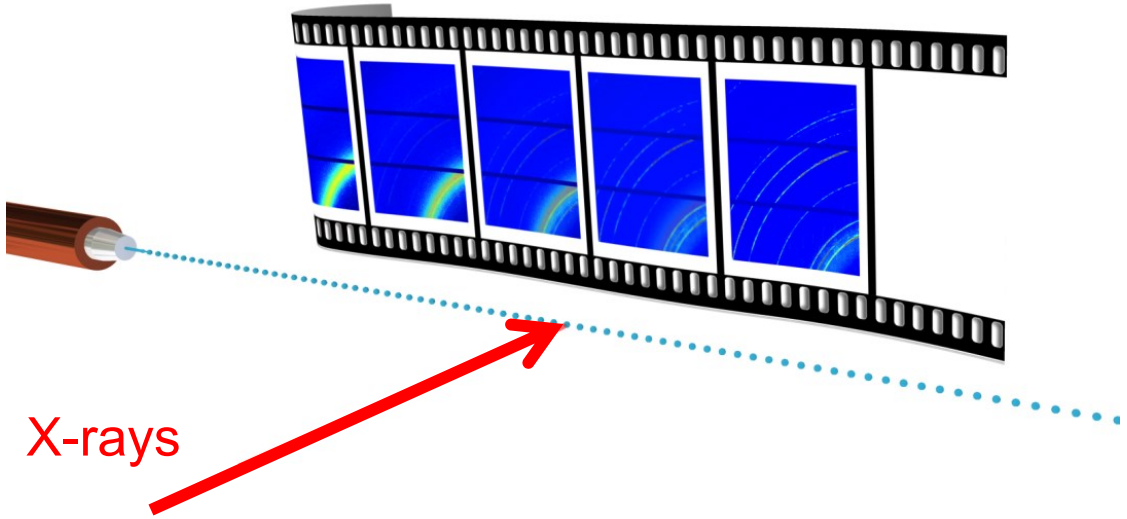
Coil cryostat



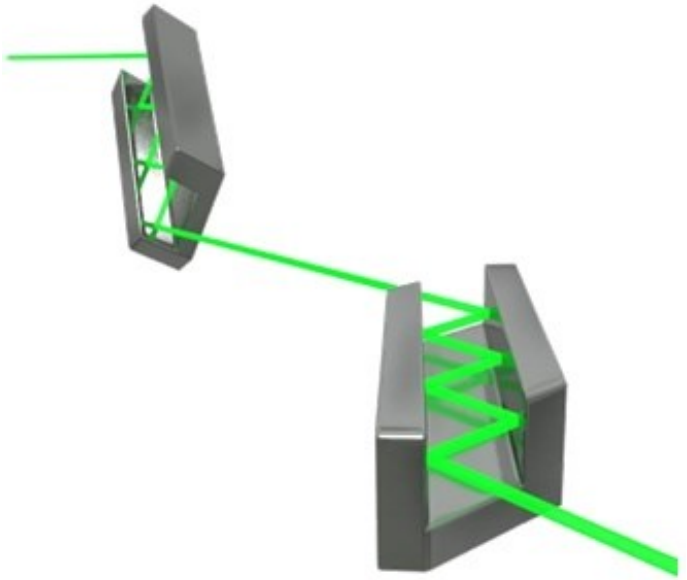
Slide from XFEL's sample environment group (Schulz, Moore, Deiter, Graceffa,…)

See also poster session

Other possibilities at MID

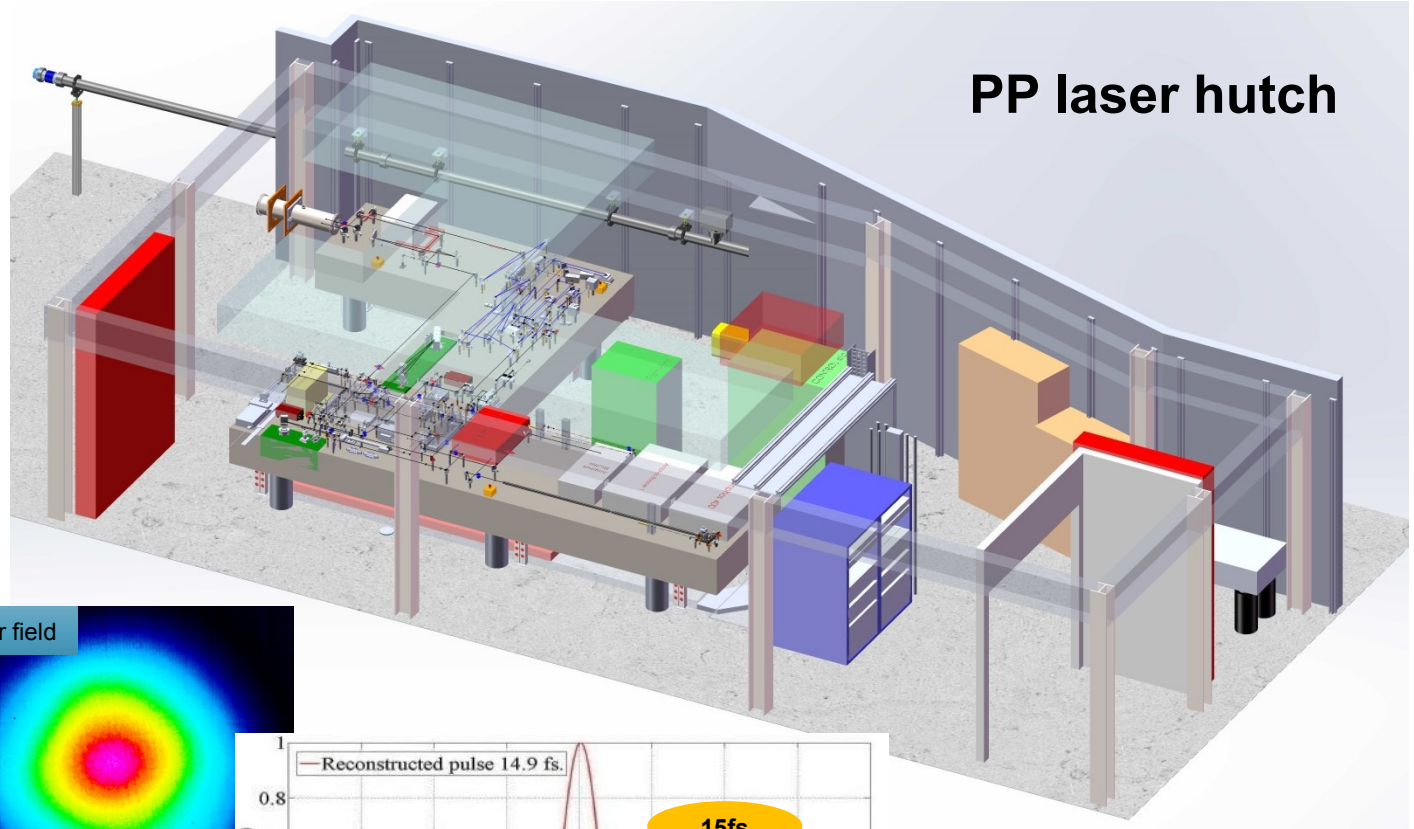


BMBF project
Cryo-jet setup
R. Grisenti et al, University of Frankfurt



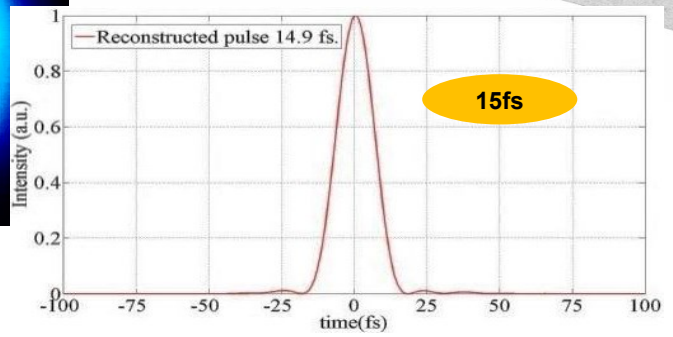
BMBF project
Polarizer-polarimeter
I. Uschmann et al, University of Jena

Pump-probe fs laser



Concept: fs-pumped NOPA stages
Down to ~ 15 fs pulse duration
Advanced cross-correlation scheme (low jitter)

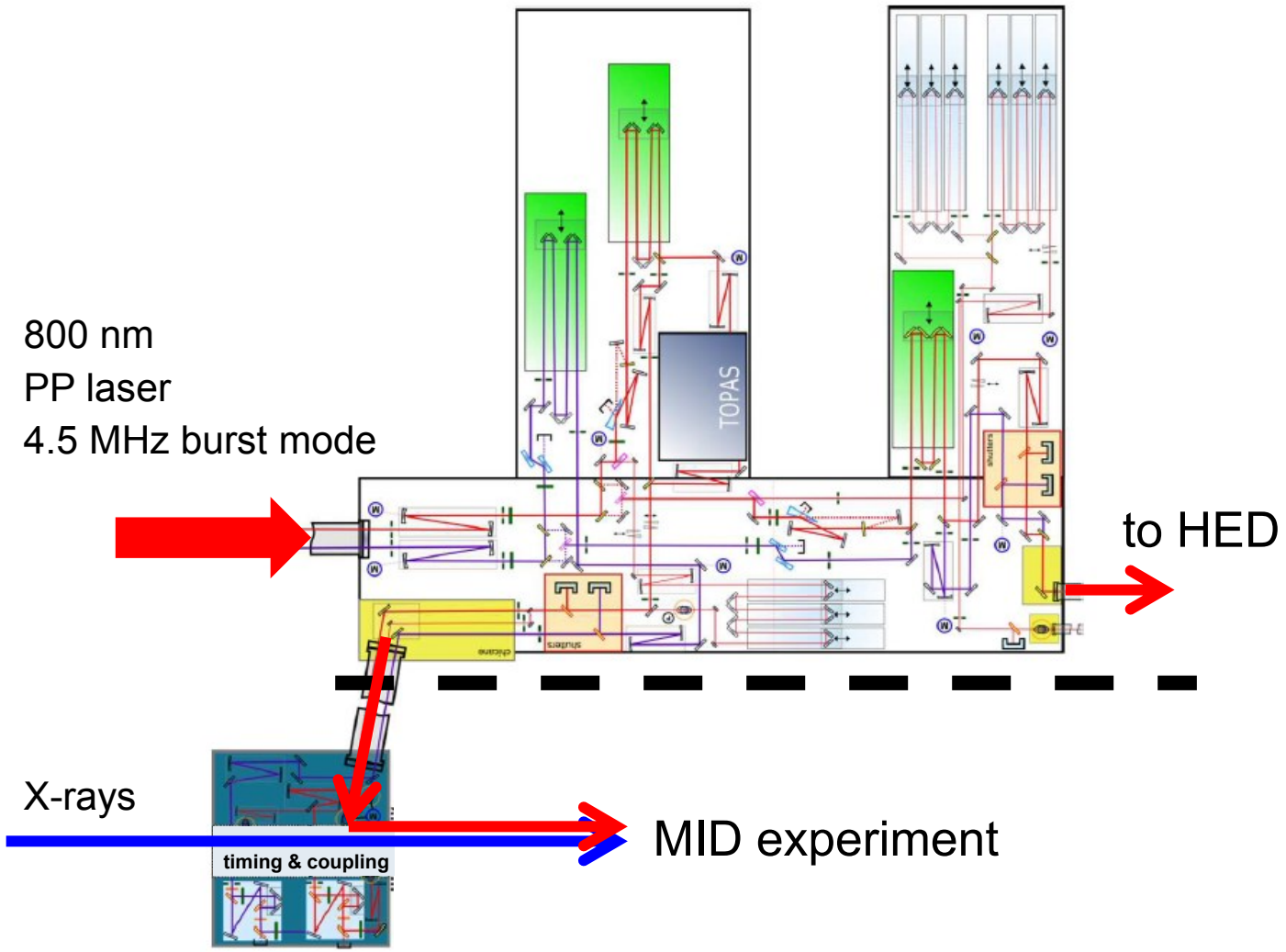
Same pulse structure
("burst mode") as the X-rays



		1030 nm		800 nm
Set point	Rep-rate (MHz)	E_{Pump} (mJ)	NOPA	E_{NOPA} (mJ)
1	4.5	1	I + II	0.05
2	1.13	4	I + II	0.3
3	0.188	21	I + II + III	1.5
4	0.1	40	I + II + III	2.5

Slide from Max Lederer
XFEL Optical Laser Group

SASE-2 instrument laser hutch

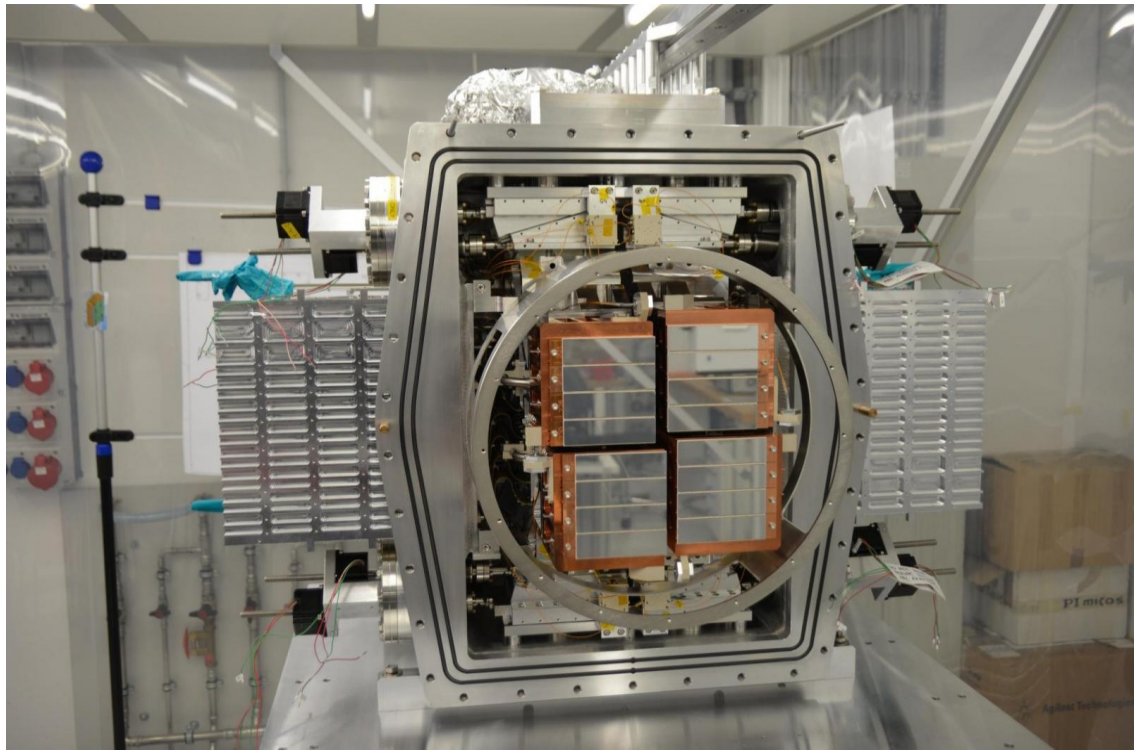


- SASE-2 laser system installation will being in April 2018 (tables and infrastructure first
- SASE-2 laser hutch follows same schedule
- Beam delivered to users not before June 2019
- Still challenges with parallel installation of PP laser at SASE-2 and SASE-3
- Laser definitely not available for first batch of user experiments at SASE-2
- THz generation under study (lower rep rate)

AGIPD detectors

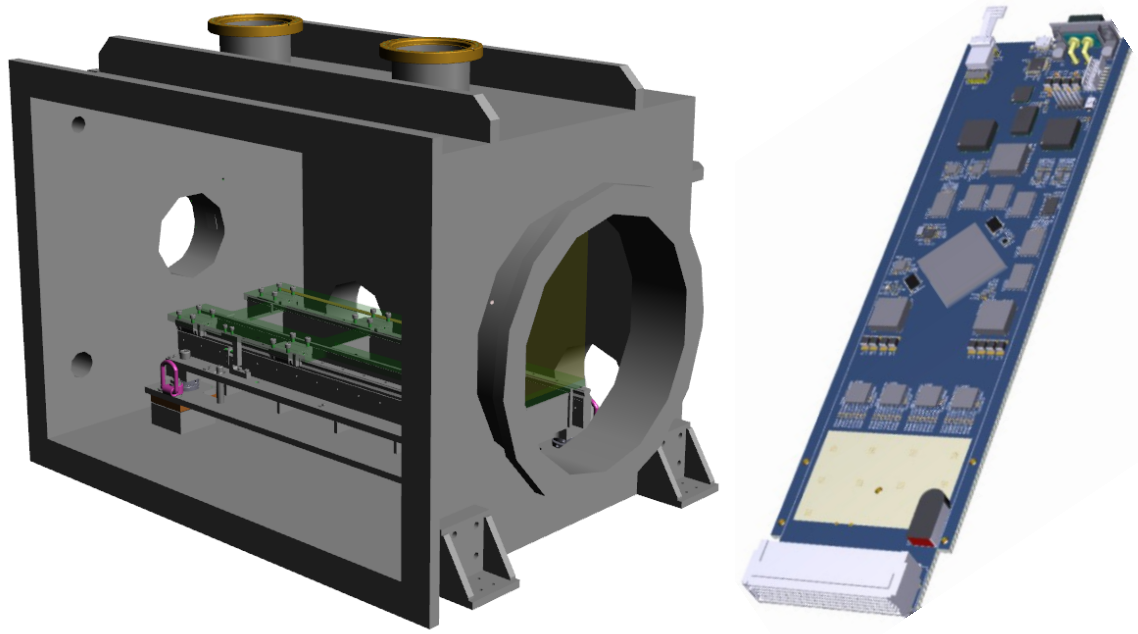
AGIPD for MID (similar to SPB's AGIPD)

- ~1M pixels, 200 μm pixel size
- MHz rep rate
- Will be available for 1st user experiments at MID



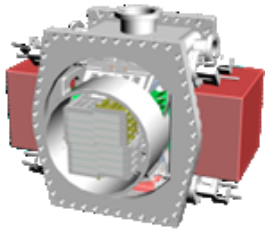
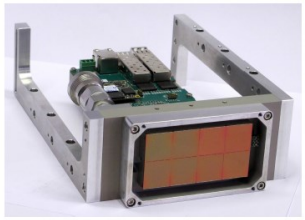
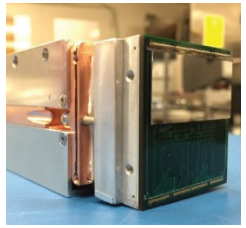
HiBEF AGIPD for HED

- Differences with respect to other AGIPD: high-Z sensor, mechanics, electronics,..
- Optimized for photon energies > 25 keV
- Still under design/development



AGIPD consortium: coordinator H. Graafsma
Slide adapted from Aschkan Allahgholi

Other detectors

	AGIPD 1M	JUNGFRAU 1M	ePix 100 1M	GOTTHARD (-II)
				
Energy range (keV)	3-25	3-25	3-20	3-25
Dynamic range	10^4 ph/px/pulse @12 keV	10^4 ph/px/pulse @12 keV	100 ph/px @8 keV	10^4 ph/px/pulse @12 keV
Pixel size	200 × 200 μm^2	75 × 75 μm^2	50 × 50 μm^2	50 (25) μm
Noise	~1000eV	~200eV (HG)	<200eV	<750eV
Repetition rate	4.5 MHz	Currently 200kHz	120Hz	800kHz (4.5 MHz)
Number of storage cells	352	16	-	(Compact storage for full pulse train)
In-vacuum	Yes	Yes	Yes	No
(#mod) Array size	(4) 110×110mm^2 /mod	(2)40×80mm^2 /mod	(2)35×38mm^2 /mod.	(1) ~6×64mm^2 1280 (2560) pxl

Timeline

- Most infrastructure installations completed: Feb-Mar 2018
- Lasing and beamline commissioning to start: April-May 2018
- Instrument, cable/electronics, and laser installations continue in parallel
- Thereafter: Instrument commissioning will start…
- MID: Early User Experiments foreseen in Jan 2019
- HED: Commissioning with x-rays start in Jan 2019

3rd call for proposals (~Nov ‘18 – June ’19):

- Both instruments will participate in 3rd call for experiments to open soon
- HED: Amplitude laser, SDL and Diamond Anvil Cell potentially available
- DIPOLE laser commissioning at HED
- Pump-probe laser for MID and HED not available for user experiments in 3rd call
- X-ray energy around 9 keV, awaiting undulator commissioning…
- 1, 30 … 300 pulses/train, MHz rate
- MID: Split-Delay Line not available in 3rd call

Acknowledgments

All groups at European XFEL, scientific collaborators, contractors, and future users (WS Mon-Tue)

INFO: **www.xfel.eu/facility/instruments/mid/index_eng.html**
www.xfel.eu/facility/instruments/hed/index_eng.html