

update: **HED science instrument**

European XFEL Users' Meeting

January 29, 2014

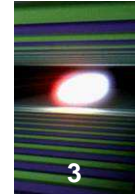
Thomas Tschentscher for HED

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Scope of this talk

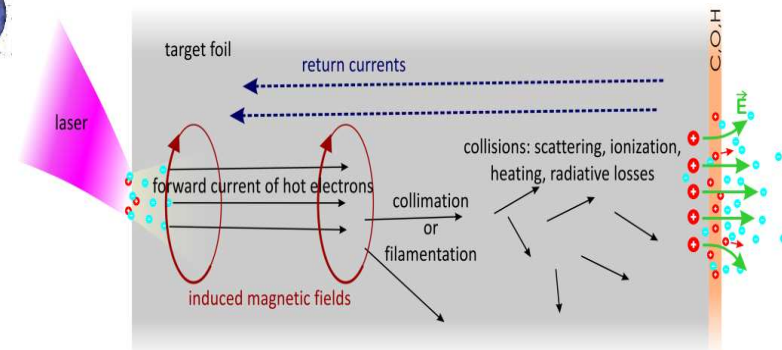
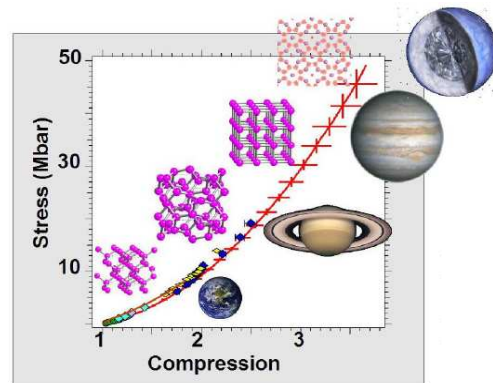
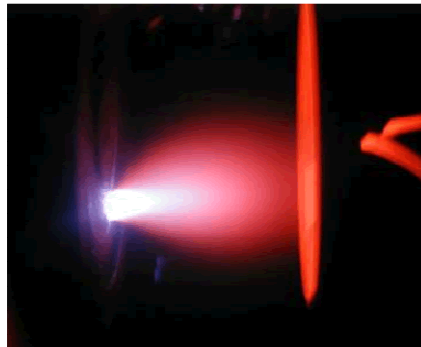


- Overview
- Detailed experiment requirements
- Next steps



Ultrafast dynamics and structural properties of matter at extreme states

- Highly excited solids → laser processing, dynamic compression, high B-field
- Near-solid density plasmas → WDM, HDM, rel. laser-matter interaction
- Quantum states of matter → high field QED



Samples generated by pulsed excitation

- Highly dynamic and often non-equilibrium
- Irreversible processes → sample refreshment required

Combination of high excitation with various x-ray techniques

- Use of various pump sources to excite samples (OL, XFEL, ext. fields)

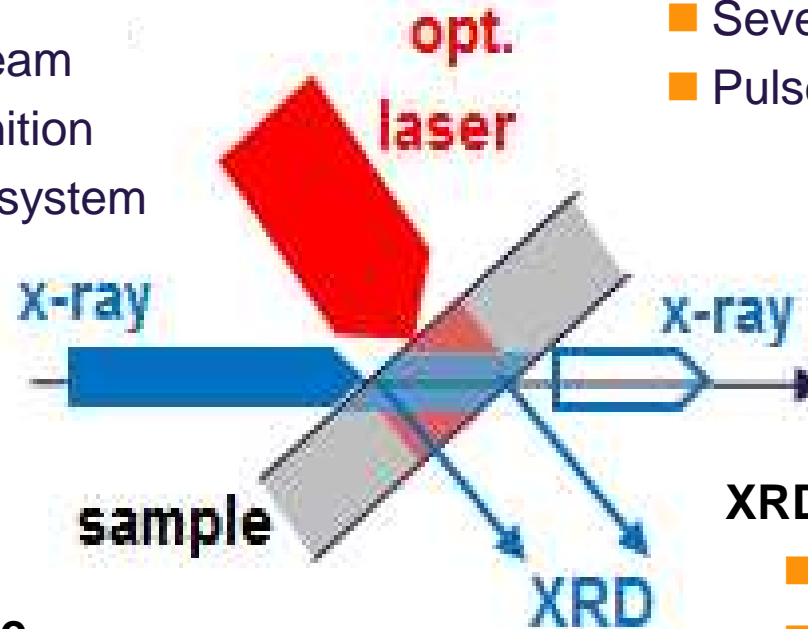


X-ray in

- Mostly probe beam
- Parameter definition
- X-rays delivery system

Optical laser

- Principal pump
- Several systems
- Pulsed magnets



Sample

- Typically: Solid
- Fast exchange
- Fabrication

XRD / x-ray out

- Structural probes
- Spectrometers
- Detectors



Completed, reviewed and published Conceptual Design Report (CDR)

- Reported at last UM
- XFEL.EU TR-2013-003; see www.xfel.eu/publications/internal-reports

Prepared Experiment Hall infrastructure requirements

- Room definition (scope & sizes)
- Infrastructure requirements (media, AC, power)

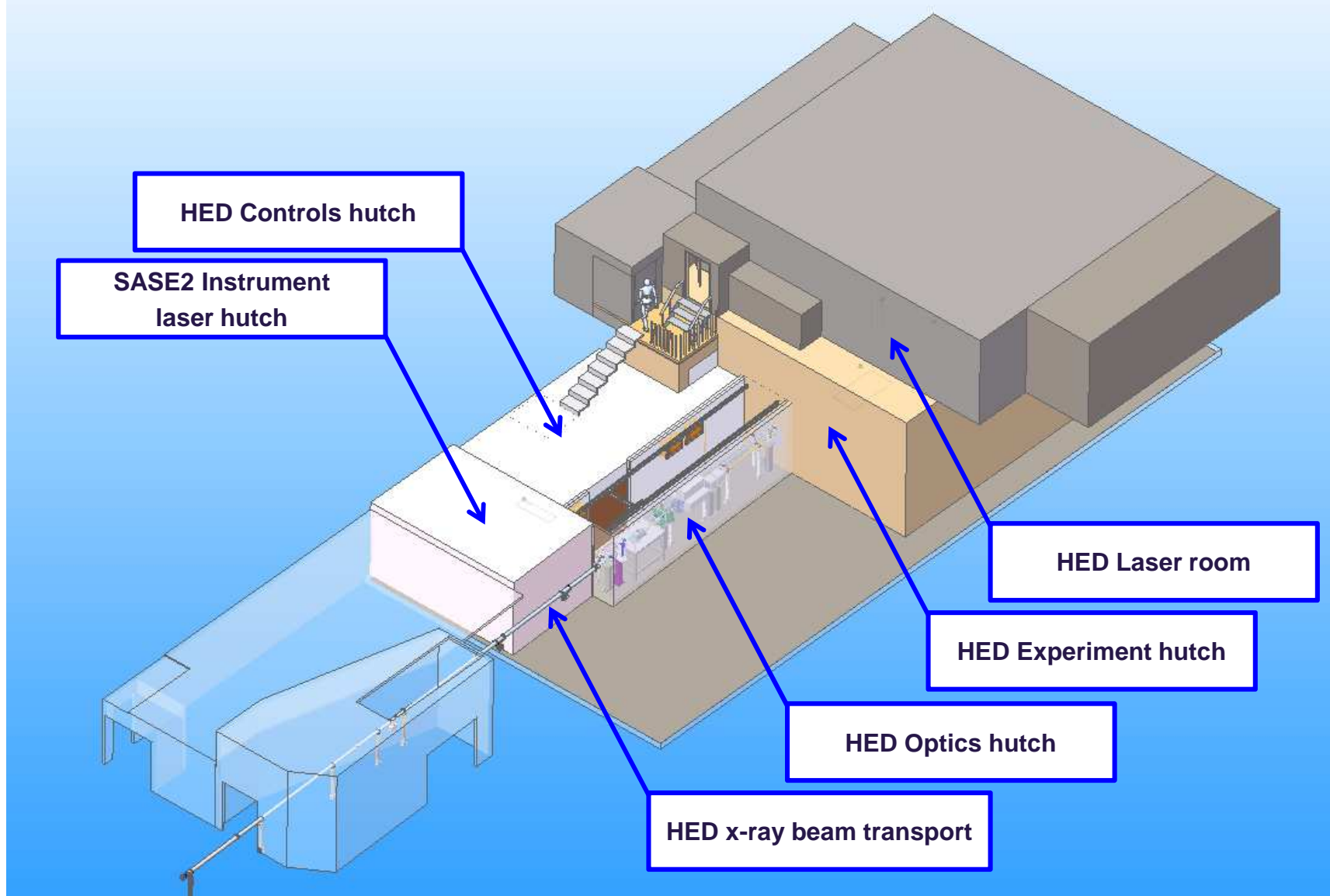
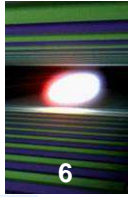
Launched civil construction of HED bits

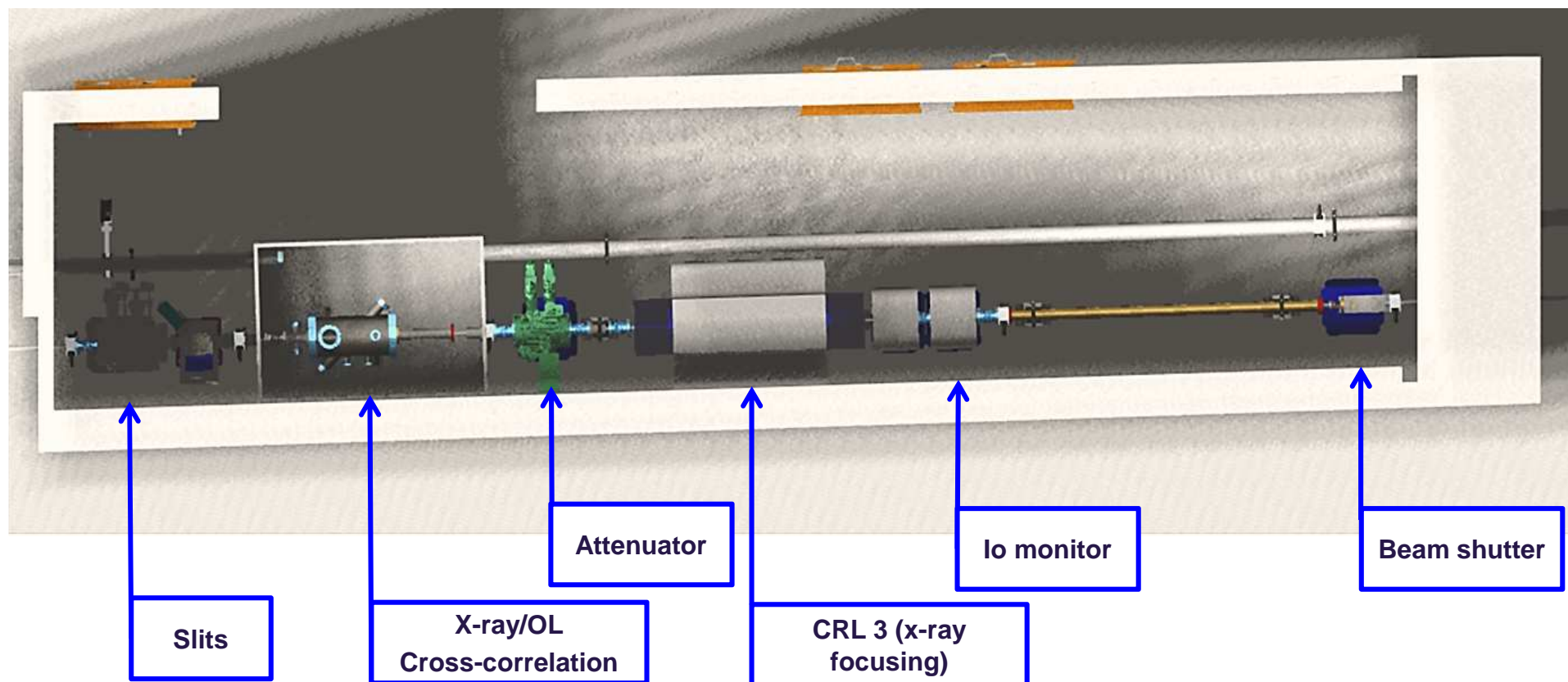
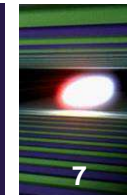
- Laser tunnel (early construction with other tunnels surrounding Exp. Hall) *
- HED-EXP using heavy concrete (early construction due to weight)

Started to define ,standard' x-ray beam delivery units (→IKC)

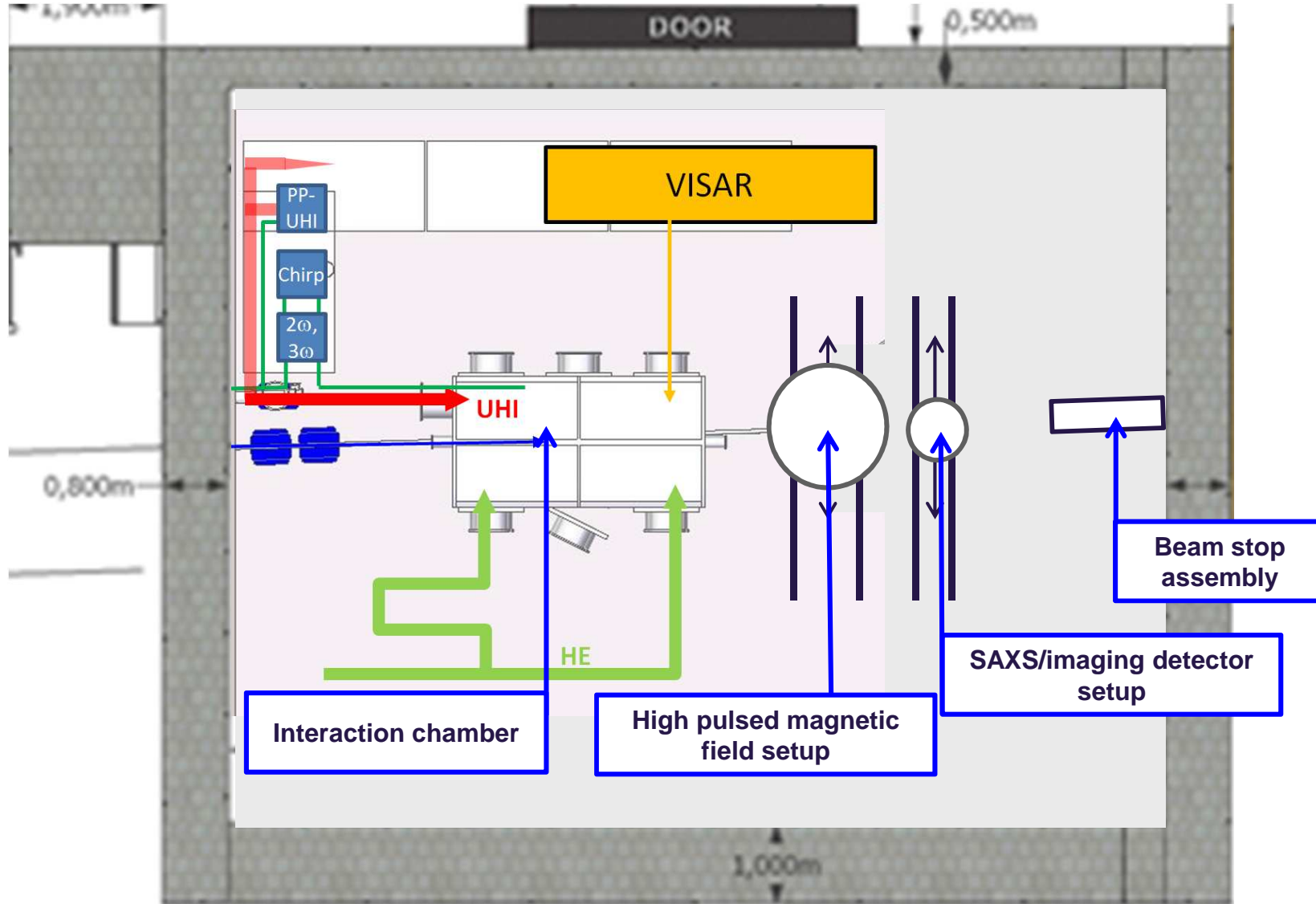
Distributed & evaluated questionnaire *Detailed Experiment Requirements*

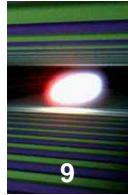
Refined HED model



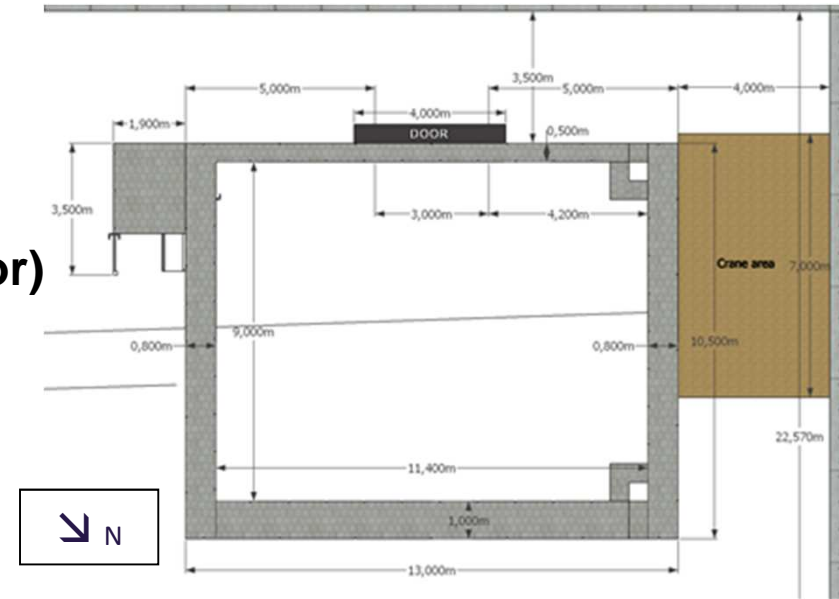
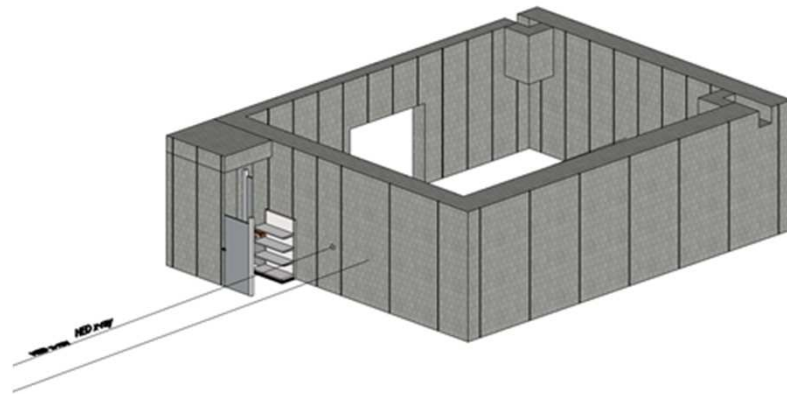


HED experiment hutch

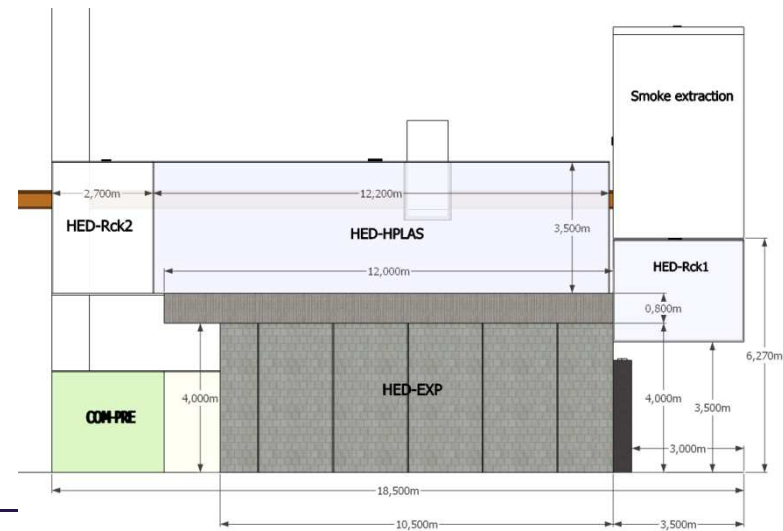




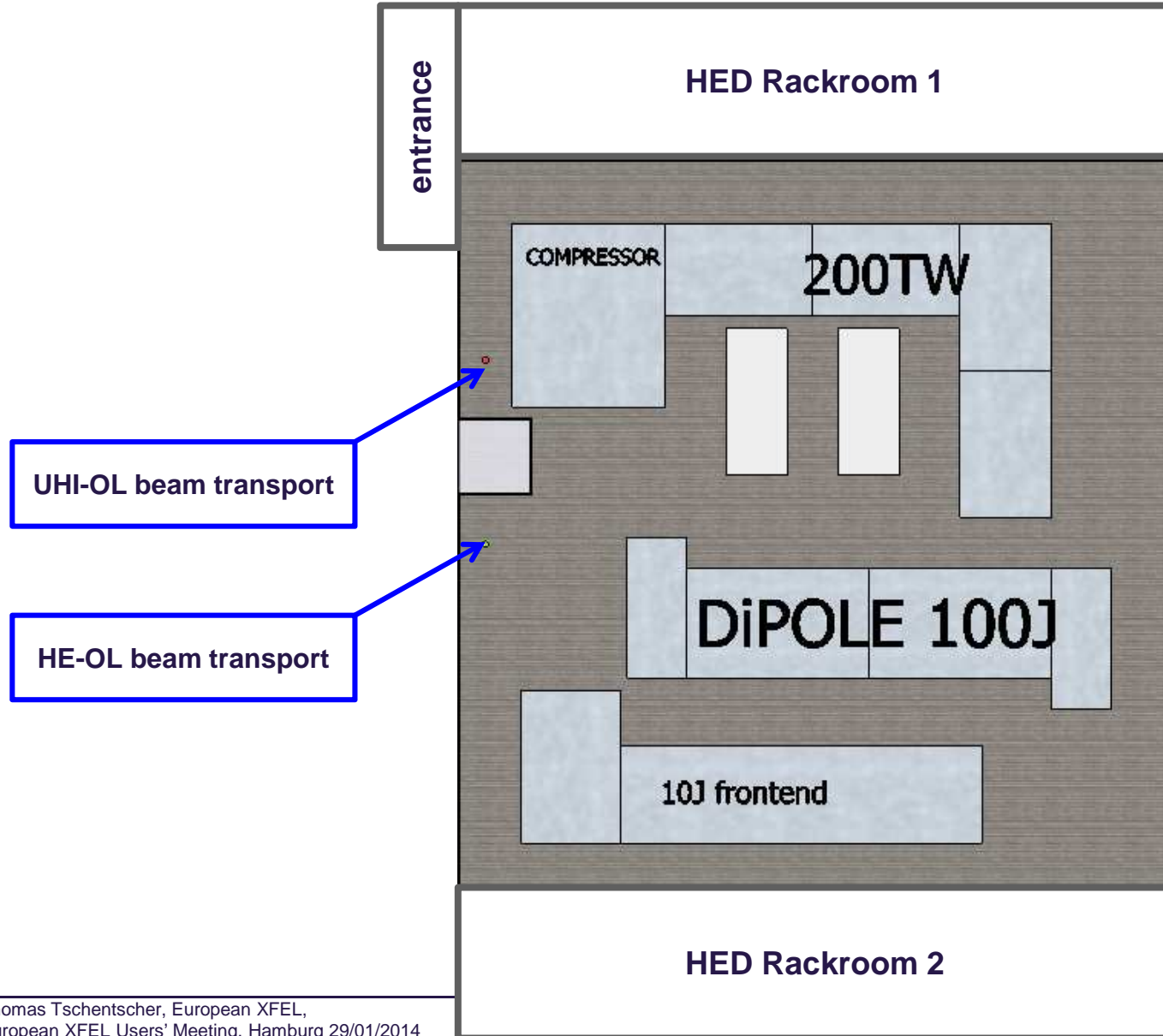
- Nov 2013** **Technical specifications**
- Dec 2013** **Call for tender**
- Jan 2014** **Award contract**
- Jun 2014** **Completion (concrete & door)**



Wall	Description	Wall thickness
East	Entrance for x-ray FEL, entrance for PP-OL beams	0.8 m, heavy iron based concrete
North	Principle laser pointing direction; distance to IA point ~4 m	1.0 m, heavy iron based concrete
West	Secondary principle laser pointing direction; distance to IA point ~6-8 m	0.8 m, heavy iron based concrete
South	Access door; opposite to principle laser pointing direction	0.5 m, heavy iron based concrete
Roof	Access door; entrance for UHI- and HE-OL beams; height 2.6 m above IA point	0.88 m, normal concrete



HED laser room





Refined list of requirements for HED science applications

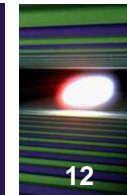
- X-ray beam parameters
- Optical laser parameters
- Detectors & spectrometers
- Sample preparation & insertion
- Details about procedures

Expert users (~10)

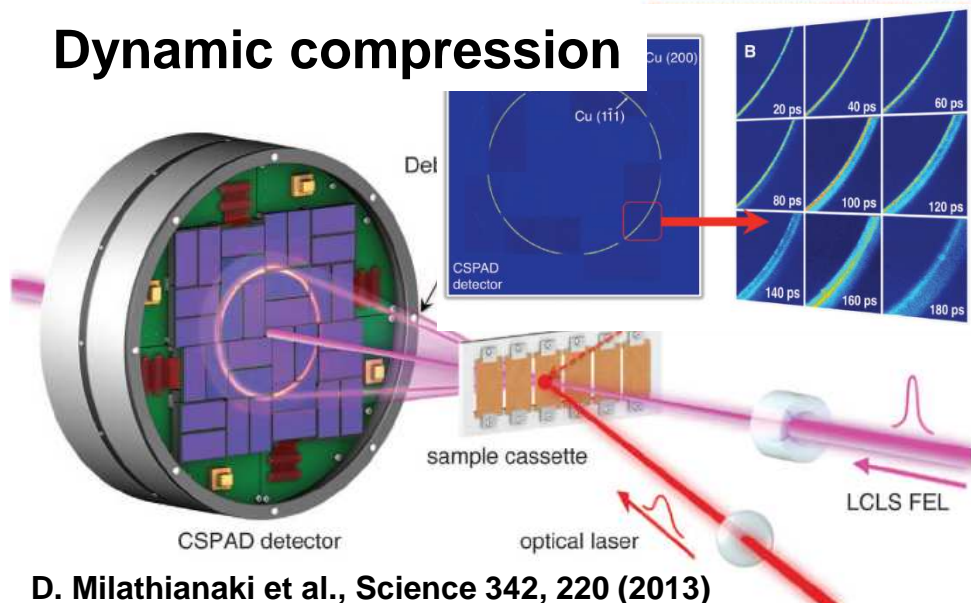
- Correspondents for certain type of HED application

Observations

- MEC experiments are very valuable experience

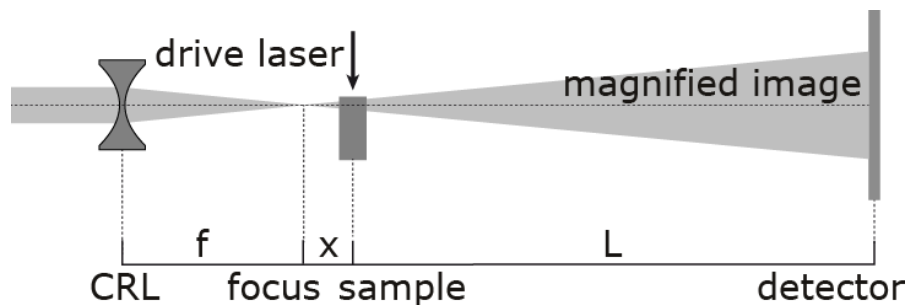


Dynamic compression



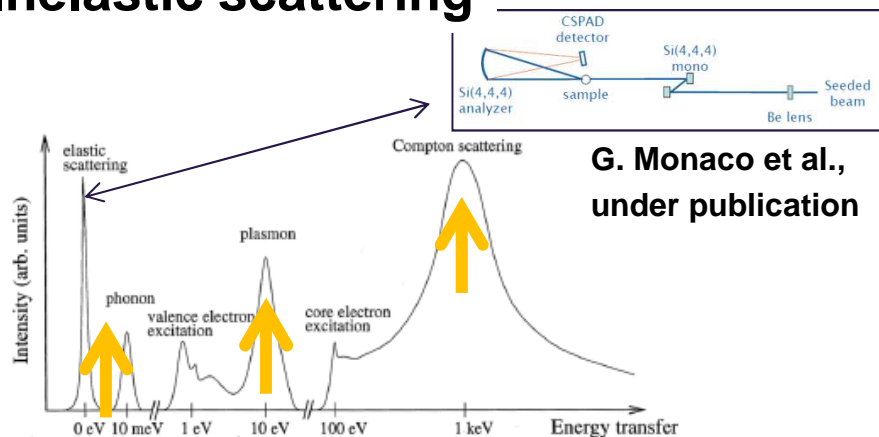
D. Milathianaki et al., Science **342**, 220 (2013)

Imaging density modulations



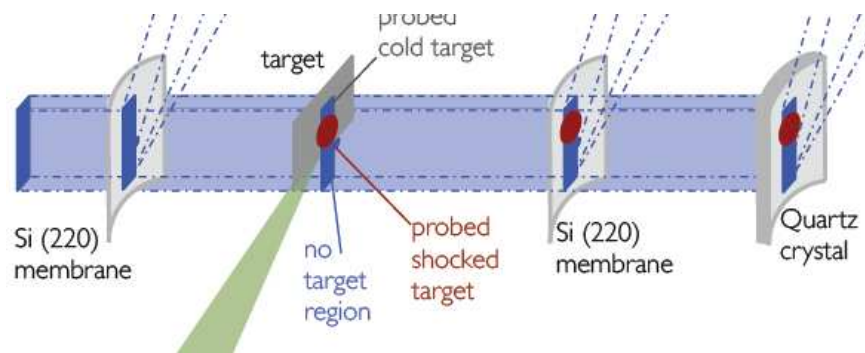
A. Schropp et al., Scientific Reports **3**, 1633 (2013)

Inelastic scattering



G. Monaco et al., under publication

X-ray absorption spectroscopy



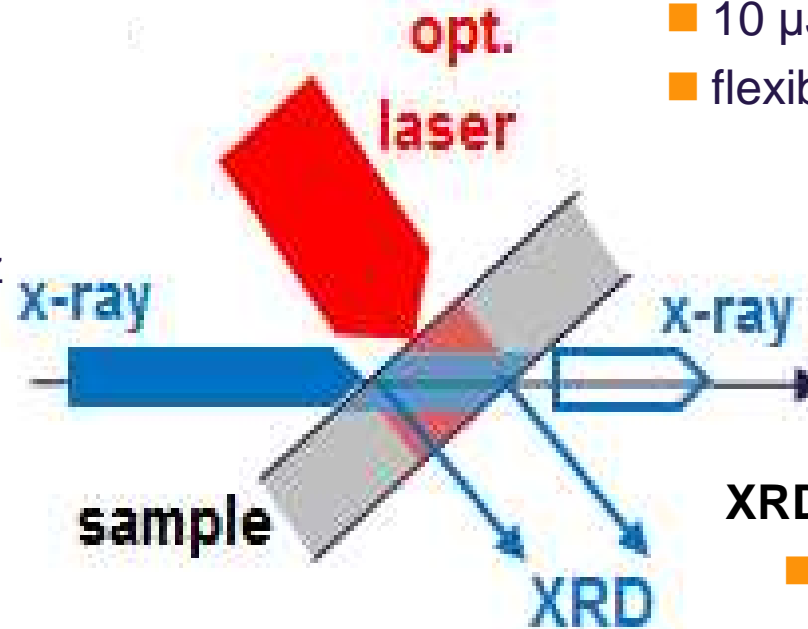
F. Dorchies, J. Gaudin, A. Ravasio, M. Harmand, et al., under publication

Some details about experiments at HED



X-ray in

- 3 – 25 keV
- 10^{-5} – 10^{-1} bw
- <1 – 200 μm
- p.o.d – 4.5 MHz



Optical laser

- 30 fs – 10 ns / chirp
- 10 μJ – (>)100 J
- flexible geometry

Sample

- disruptive: 2D & fast exchange
- exactness/availability/debris
- repetitive: 3D

XRD / x-ray out

- XRD/SAXS/imaging
→ area detectors
- IXS/XAS/XES → spectrometers
- specials



Technical Design Report (TDR)

- HED Users Workshop (tomorrow Thu, Jan 30, 14 – 18:30 hrs, FLASH)
 - Recent new developments
 - Discussion of HED layout & concept (TDR) with users
- Meeting of the HED Advisory & Review Team (HED-ART) (Mar 19)
 - Review TDR
- Publish TDR (end of April/early May)

Start construction

- Construction HED-EXP enclosure in June 2014
- Contracting other hutches and infrastructure before end 2014
- Construction of hutches & infrastructure completed in summer 2016

- Contracting x-ray and OL components starts now
- First x-ray beam in April 2017



HIBEF deliverables

- UHI- and HE-OL laser systems, incl. diagnostics, compressor, ...
- Pulsed magnet setup
- X-ray spectrometers, detectors, ...
- External laser building

Status

- OL definitions and interfaces have been discussed in detail
- Other contribution will be defined next
- Agreement between user consortium and European XFEL will be concluded
- First funds are expected to become available during 2014

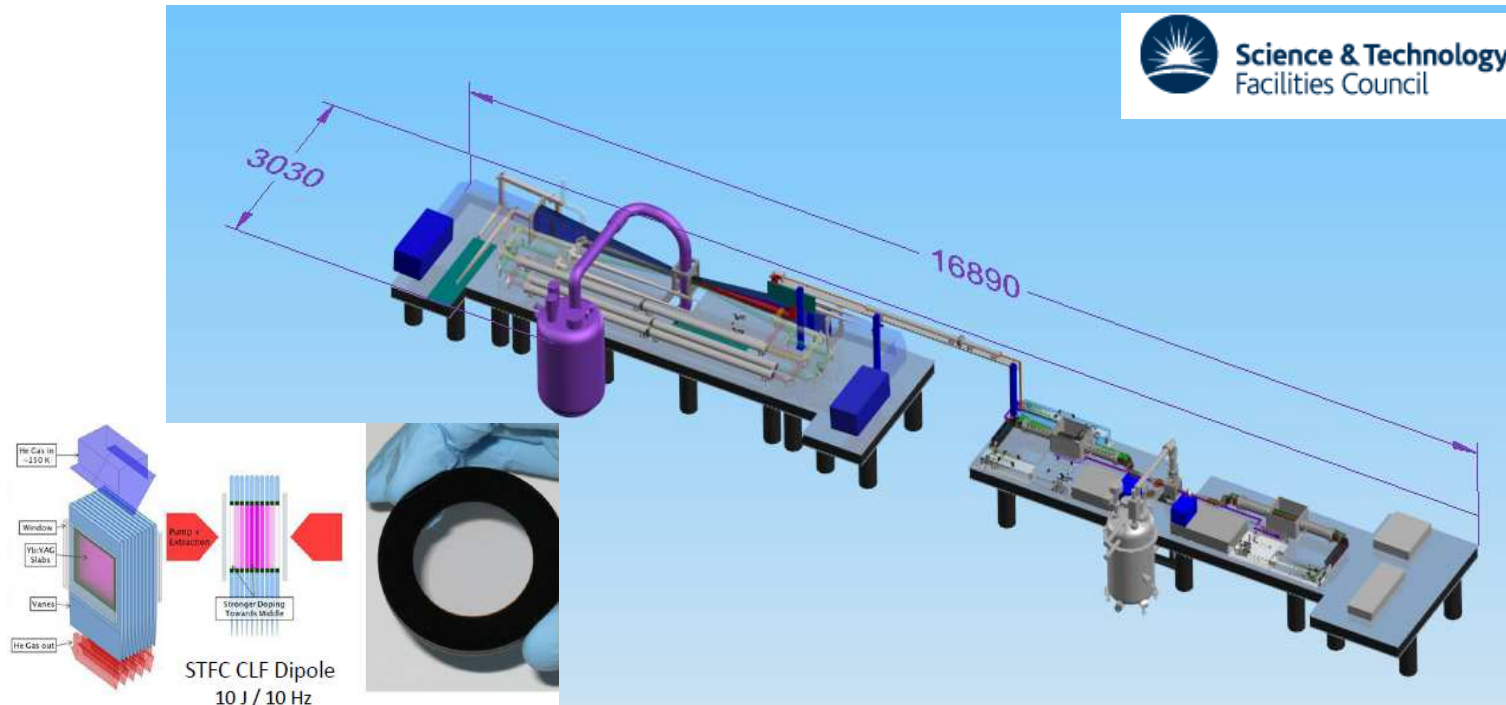
Prospect

- HIBEF team at European XFEL will build up

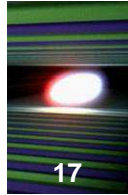


Proposal by RAL to contribute nanosecond laser to HIBEF / HED

- DIPOLE : diode pumped ns laser (ceramic :YAG)
 - **>100 J pulse energies**
 - **10 Hz repetition rate**
 - **Pulse shape configurable**
- Proposal currently under evaluation

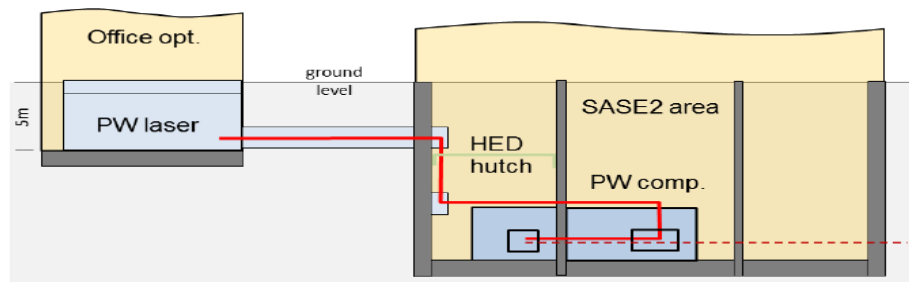


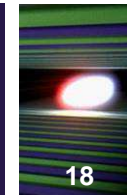
Laser tunnel connecting to (future) laser bldg



Scope

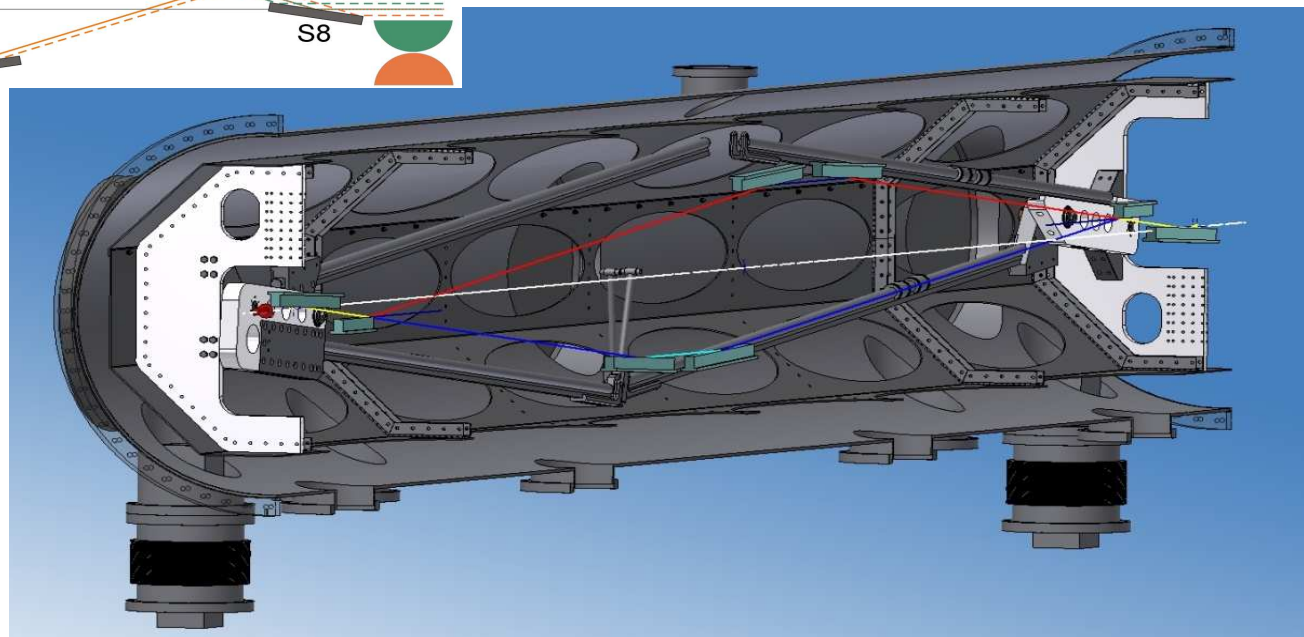
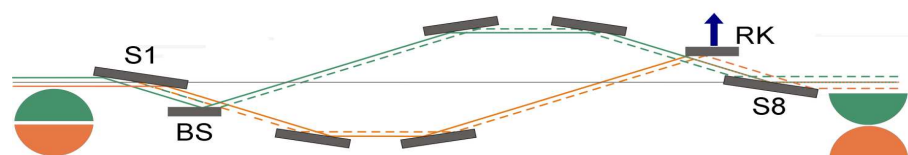
- Enable to bring large lasers to HED
- Installation in external laser bldg (to be build)
- Beam transport through tunnel to experiment hall
- Connect to MJ power supply for pulsed magnetic fields
- 2 x 2 m² cross-section





Multilayer based 8 mirror split & delay

- External contribution by U Münster funded through BMBF VF
- Installation inside x-ray beam transport for HED (WP-73)
- Delays of ~ 2 ps (20 keV) to ~ 36 ps (4 keV);
- Delaying 3rd harm vs. 1st harm.



S. Røling, H. Zacharias, et al.,
SPIE conf 8504, 850407 (2012)
BMBF project 05K10PM2



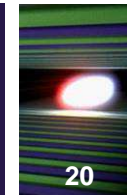
Time to 1st x-ray beam is ~3 years

- Rooms and infrastructure will be completed 2016
- X-ray delivery systems will be available 2016
- Optical lasers system will be available before start of x-ray beam
 - **Biggest challenge : HE-OL**
- ⇒ **HED instrument will be available in time for first x-rays**

HED science portfolio

- Method & instrument development on-going
 - **Dynamic compression using OLs**
 - **High resolution x-ray scattering**
 - **(Coherent) imaging techniques**
- Science applications still exploring new capabilities
 - **Pulse high magnetic fields**
 - **Materials science applications**
 - **High field QED applications**

The HED team *plus*



**Motoaki
Nakatsutsumi**



**Karen
Appel**



**Ian
Thorpe**



**Thomas
Tschentscher
(interim)**



**Alexander
Pelka
(HZDR)**



**Bruno
Mueller
(LULI)**



Laser group

Gerd Priebe, Guido Palmer & Max Lederer



CIE team

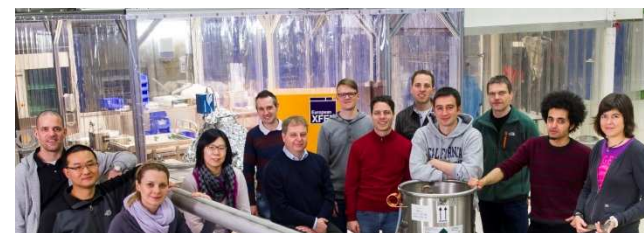
Lewis Batchelor & Antonios Lalechos



Sample environment group

Joachim Schulz & Carsten Deiter

**+ Photon diagnostics,
Detector,
DAQ/Ctrl groups**



XROBT group

Harald Sinn & Martin Dommach