

European XFEL

Prof. Robert Feidenhans'l
Chairman of the European XFEL Management Board



The European XFEL - a Status report

European XFEL

Prof. Robert Feidenhans'l
Chairman of the European XFEL Management Board



- Organisation
- From first lasing to first users
- First results
- Outlook

European XFEL Schenefeld Photon Systems



August 17 2017

- Schenefeld und Hamburg
- European User Facility for X-ray Science
- Start of operation: July 1. 2017
- First robust users 14. September 2017.



About the European XFEL

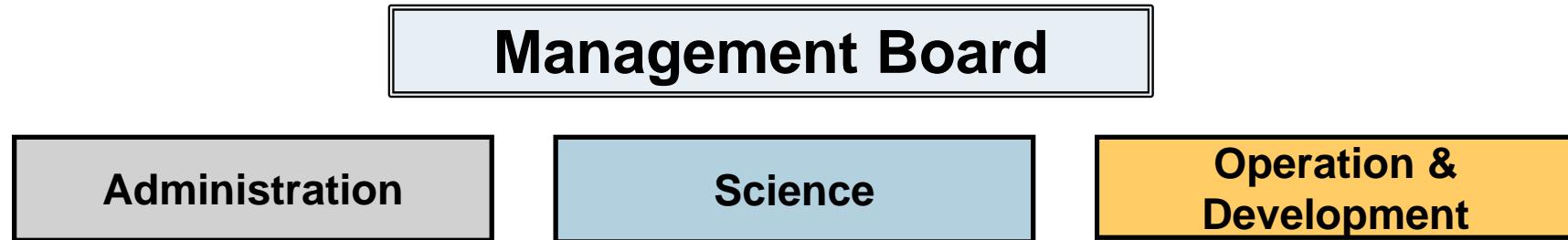
- Start 2009
- Task : Construction
- Germany 58%, Russia 25%
- DESY operates the facility
- Staff XFEL about 400 people
- Start of operation 1st November 2017
- 1,22 Mrd. € (2018)
- 600 Mio € in costs, 60% from Germany
- Yearly running costs 117,6 Mio € (2018)



FP14 Flaggenleiste mit HH und S-H? Gerade wegen letzterem.

Poppe, Frank; 30.01.2017

New organisational structure at European XFEL : 3 Divisions

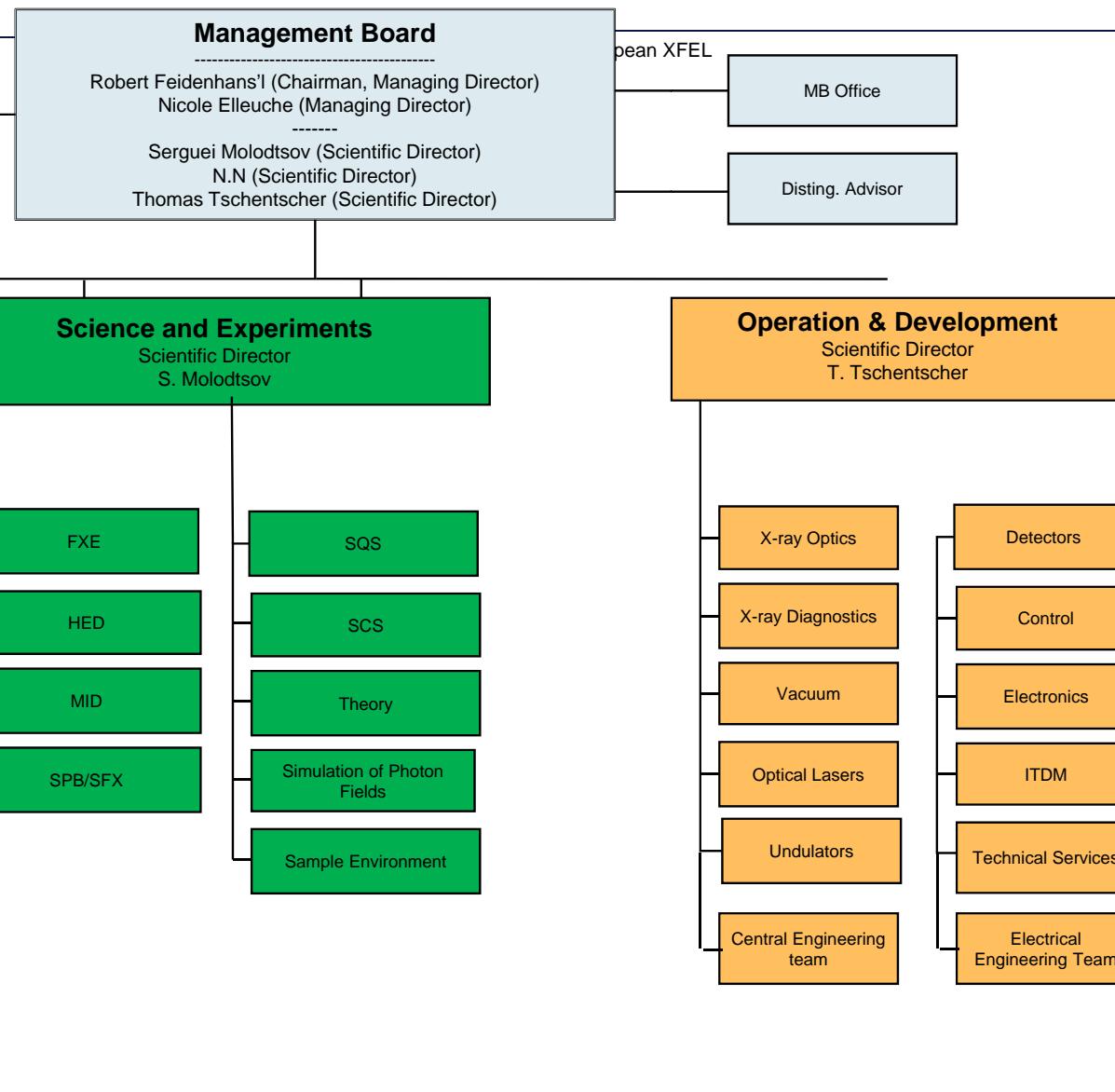


- Challenges to be met:
- We have to be more efficient and use the resources better
- Review of the Operation Cost in 2019
- **From 2019 and onwards the operation cost will be fixed (apart from escalation)**

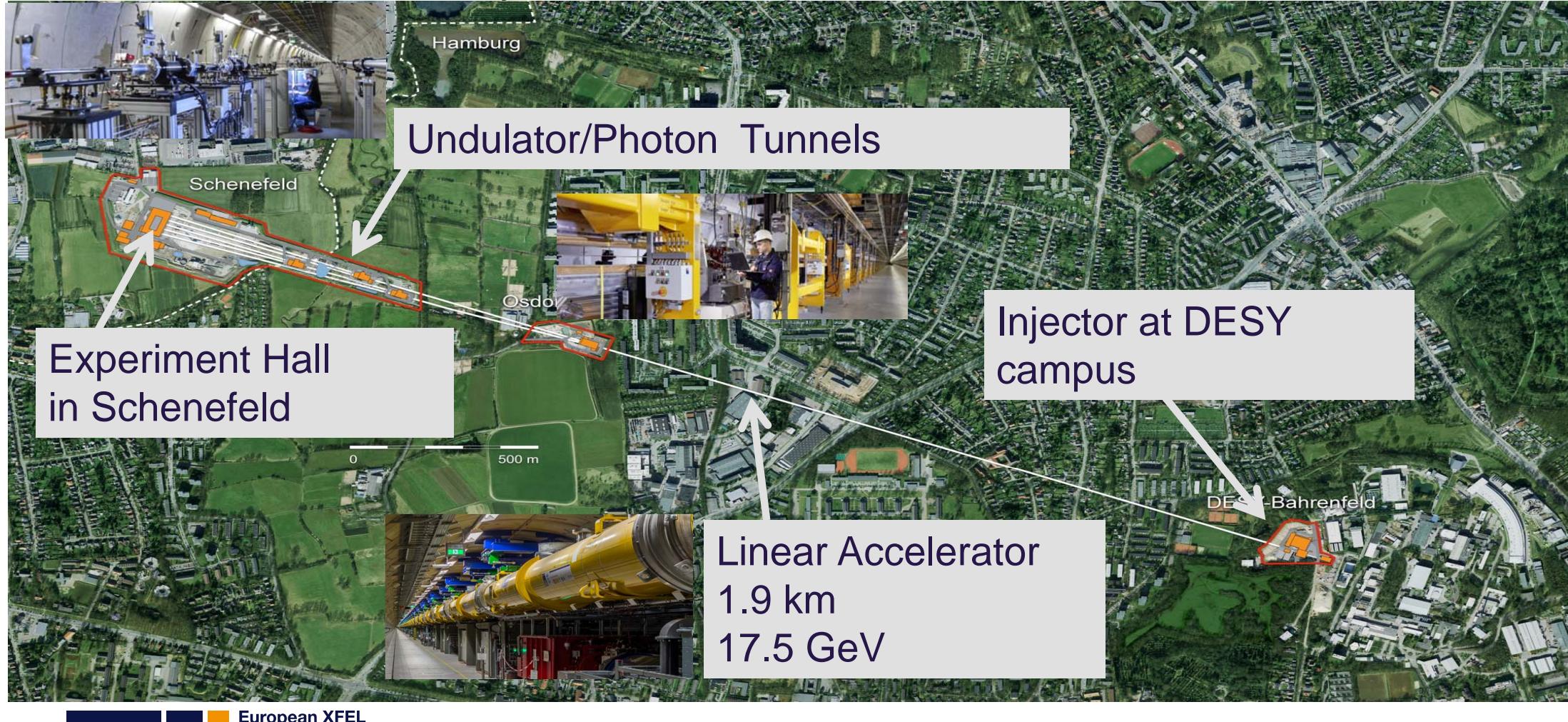
Goals for the coming 5 years

- We have to reach an acceptable work load for the Instruments
- We have to deliver 4000 hours/year of beamtime to the users for all 6 instruments
- We will offer new instrumentation to the users program
- We have to develop a vibrant R&D program
- We will work towards new instruments in SASE 4 and SASE 5

Short-Term Orga-Chart



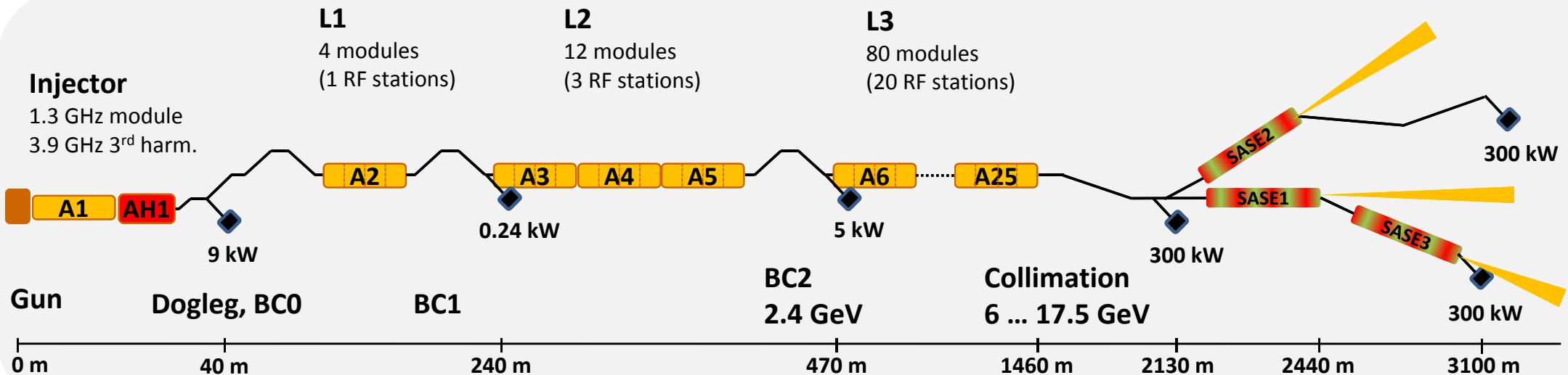
General layout of the European XFEL



European XFEL

Schematic accelerator overview

Prof. Robert Feidenhans'l, European XFEL



Courtesy Winni Decking



FEL

May 2 : Simultaneous Lasing on all three SASE

Facility Development

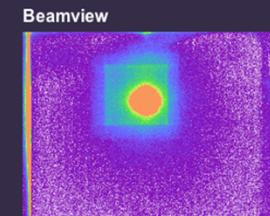


2018-05-02 14:47:20

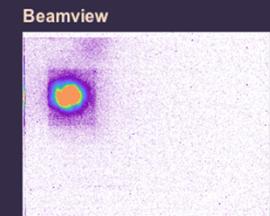
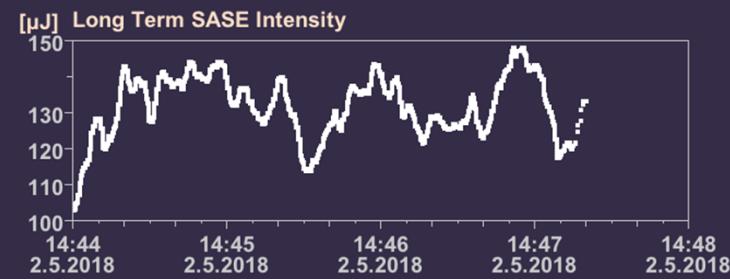
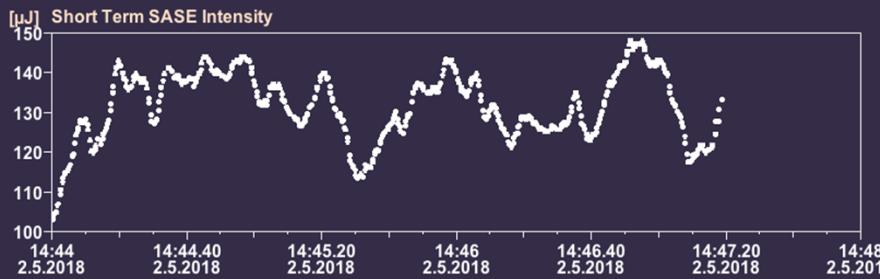
X XTD9 (SASE1) Beam Permission

X XTD6 (SASE2) Beam Permission

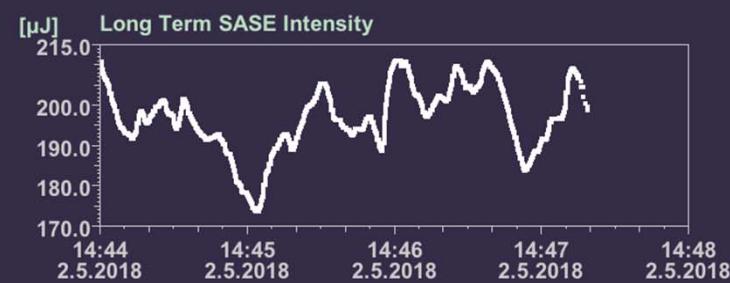
SASE 1 **240.05 μJ** **NaN % @** **9.20 keV** **1.35 Å**



SASE 2 **133.53 μJ** **@** **7.00 keV** **1.77 Å**



SASE 3 **198.91 μJ** **NaN % @** **0.70 keV** **17.71 Å**



Bear XFEL: User program

The screenshot shows the European XFEL User Program interface. At the top, there are two logos: "European XFEL" and "DESY". The main area displays beam parameters and timing diagrams. On the left, a graph titled "Record" shows photon flux over time, with a yellow arrow pointing to "Block 7" and a value of 84%. Below this is a legend:

- Interlock broken (blue line)
- Temporary access (dotted line)
- Interlock set (black line)
- No beam in section (white box)
- Electrons in section (blue box)
- Photons in section (yellow box)

On the right, there are several sections with specific parameters:

- 0 bunches:** 14016 MeV, 0.27 nC
- 60 bunches:** 60 bunches
- 60 bunches:** 60 bunches
- 9300 eV:** 1495 µJ
- 900 eV:** 41 µJ
- HED MID:**
- FXE:**
- SQS SCS:**

At the bottom, there is a summary table:

Accelerator:	Beam for Photon Delivery
SASE1:	Photon Delivery between 8 and 10.5 keV
SASE2:	-
SASE3:	Parasitic lasing 900 eV

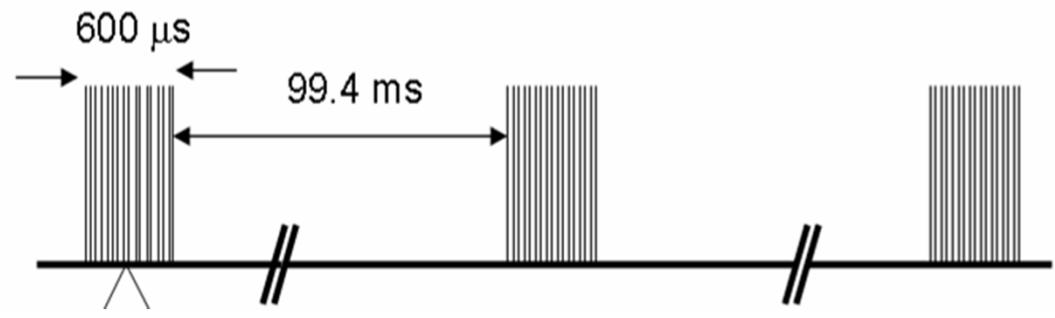
On the far left, a vertical list of bullet points is visible:

- Available
- Little variation
- Program
- In general: the technical systems show **excellent** performance

At the bottom right, the date and time are shown: 2018-06-14 16:22.

Key parameters of European XFEL

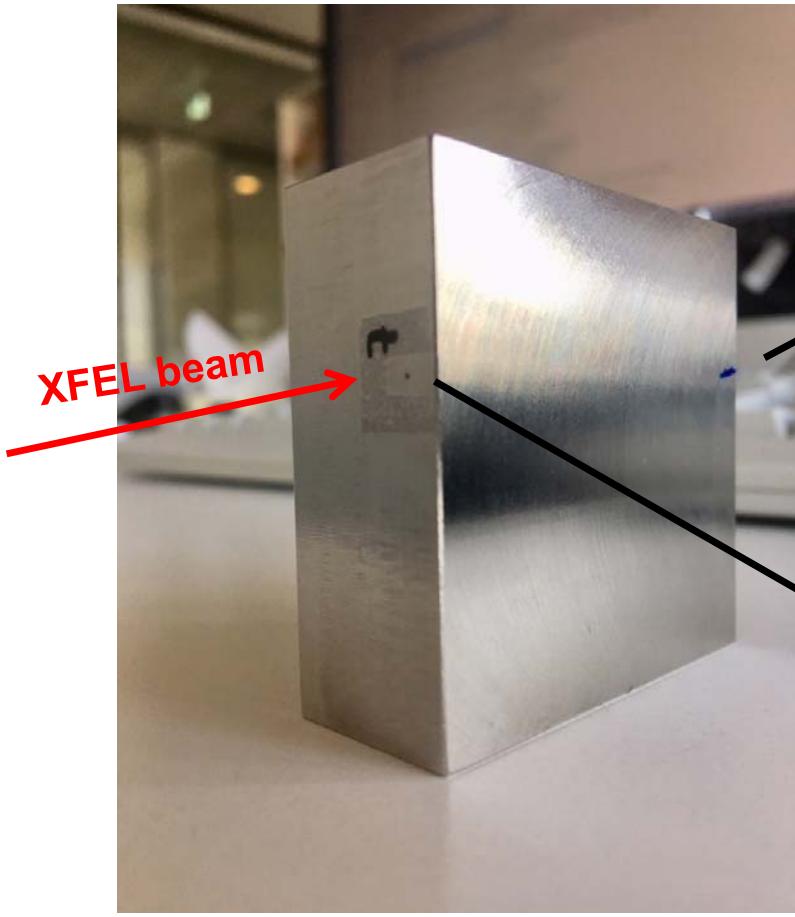
Parameter	Value
Electron Energy	8.5 – 17.5 GeV
Photon energy	0.26 - >25 keV
Pulse duration	2 – 100 fs
Seeding	In preparation
# of pulses	27000 /s
# of FELs	3
# of instruments	6
Start of operation	2017



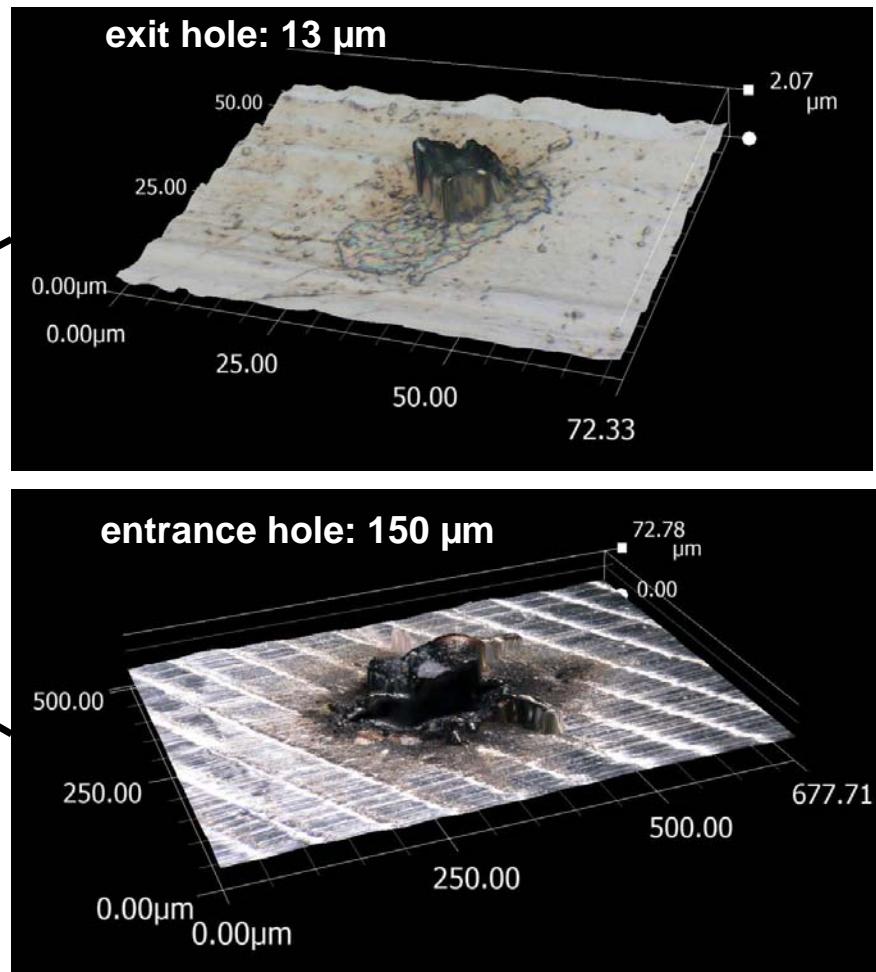
- Specific electron & x-ray beam delivery pattern
- Follows from pulsed RF system
- Trains of e-/x-ray pulses
- Max. = 2.700 per train / 27.000 per sec

- High average brilliance
- Feedback & time and space stabilization
- Dedicated pulse delivery

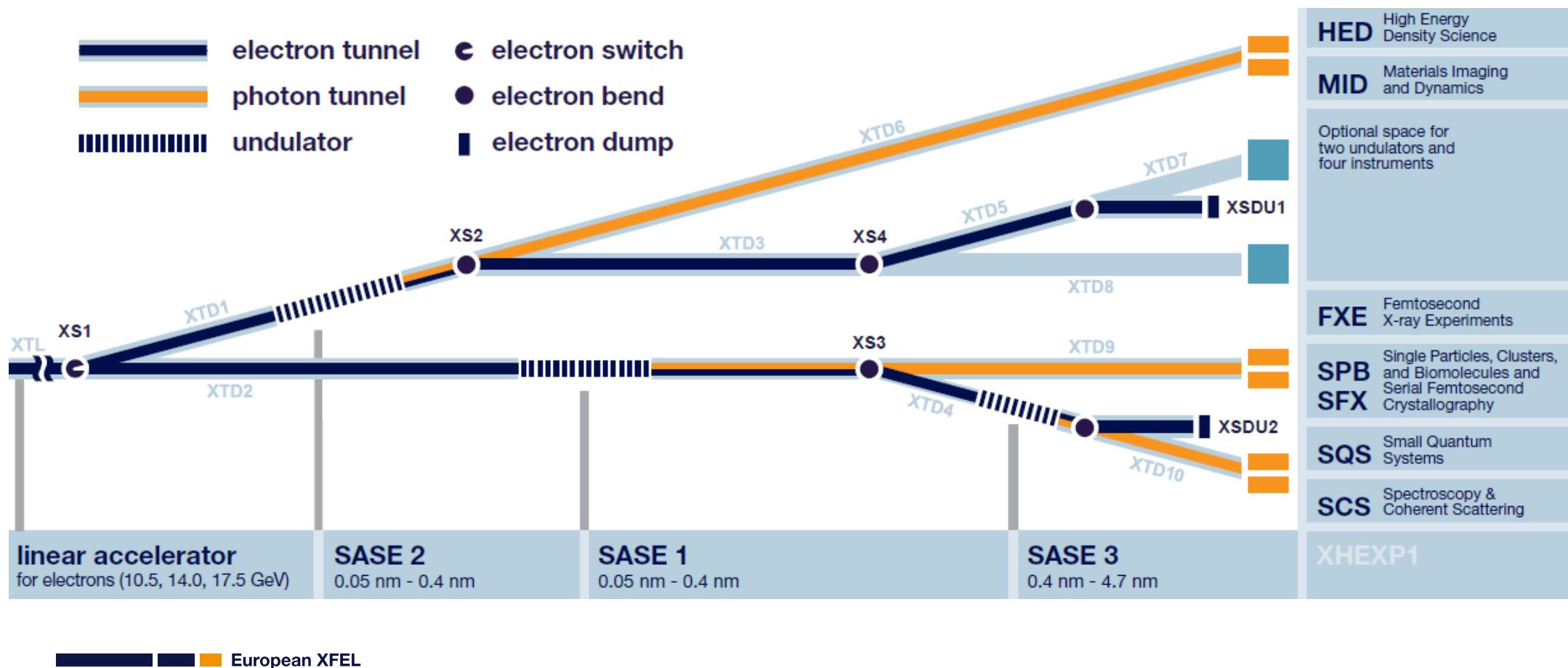
We have an exceptionally strong beam:
Drilling with XFEL beam through 50 mm of steel in 26 seconds



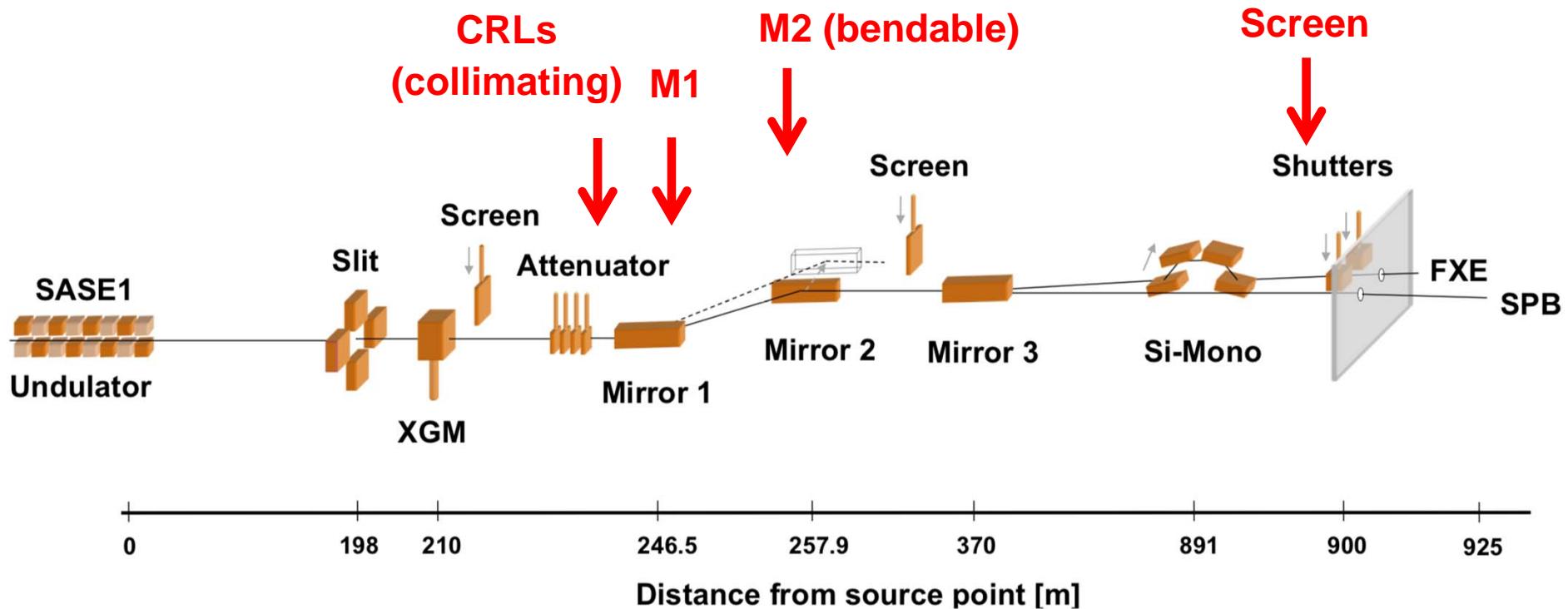
Courtesy Harald Sinn



Experimental Hall



Photon Beamline SASE1



Scientific instruments

FXE (Femtosecond X-ray Experiments)

- Ultrafast dynamics of liquids and solid matter
- Combination of spec. & scat. techniques

Team: Ch. Bressler et al.

MID (Materials Imaging & Dynamics)

- CDI from nano-structured samples
- XPCS of nanoscale dynamics

Team: A. Madsen et al.

SQS (Small Quantum Systems)

- Ultrafast dynamics of atoms, ions & clusters
- Combination of spec. & coh. scat. techniques

Team: M. Meyer et al.

SPB/SFX (Single Part., Bioimaging, & SFX)

- Coherent diffraction imaging from single part.
- Serial fs nano-crystallography

Team: A. Mancuso et al. / **SFX UC** (H. Chapman et al.)

HED (High Energy Density science)

- Ultrafast dynamics of highly excited matter
- Combinations of scattering, diff. & spectroscopy

Team: U. Zastrau et al. / **HiBEF UC** (T. Cowan et al.)

SCS (Spectroscopy & Coherent Scattering)

- Ultrafast dynamics of complex solids
- Combination of hr-inelastic spec. & coh.scattering

Team: A. Scherz et al. / **hRIXS UC** (A. Föhlisch et al.)

Users Statistics Proposal round 1 and 2

Beamtime Allocation Period	201701 (Sep.-Dec. 2017)	201801 (Aug.-Oct. 2018)
Proposals submitted	63	61
Total proposers	505	440
User shifts requested	275	341
Proposals for FXE	37	42
Beamtime allocated	7	6
Proposals for SPB/SFX	26	19
Beamtime allocated	7	6
Users in Sep.-Dec.		
Users visits Schenefeld	463	
Remote access users	41	
Individual users	341	

Outline Annual Operation Schedule 2019 (FINAL-2, 28/08/2018)

Legende:

- Weekend
- Bank holiday
- Scheduled down
- RP
- ST
- FD
- XP

2019	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th
Program																															
Feb	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th			
Program																															
Mrz	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su
Program																															
Apr	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	
Program																															
Mai	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr
Program																															
Jun	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	
Program																															
Jul	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We
Program																															
Aug	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa
Program																															
Sep	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	
Program																															
Okt	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th
Program																															
Nov	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	
Program																															
Dez	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu
Program																															
Jan	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr
2020																															
Program																															

RP Radiation protection

ST Setup, access, tuning

FD Facility development

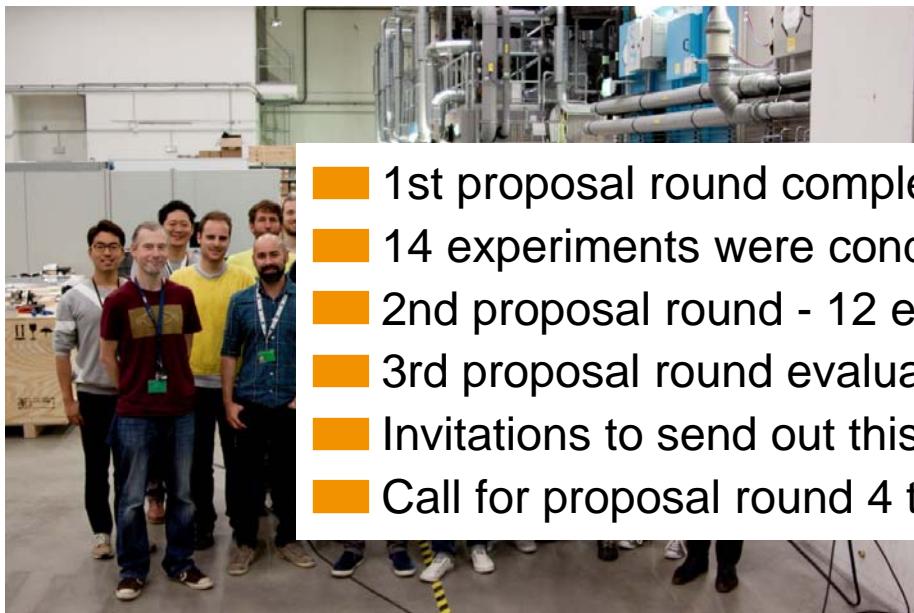
XP X-ray program

TEST : 24 hours user mode

The X-ray program

Includes external (user) and internal commissioning and other internal use

First users – September 14 2017

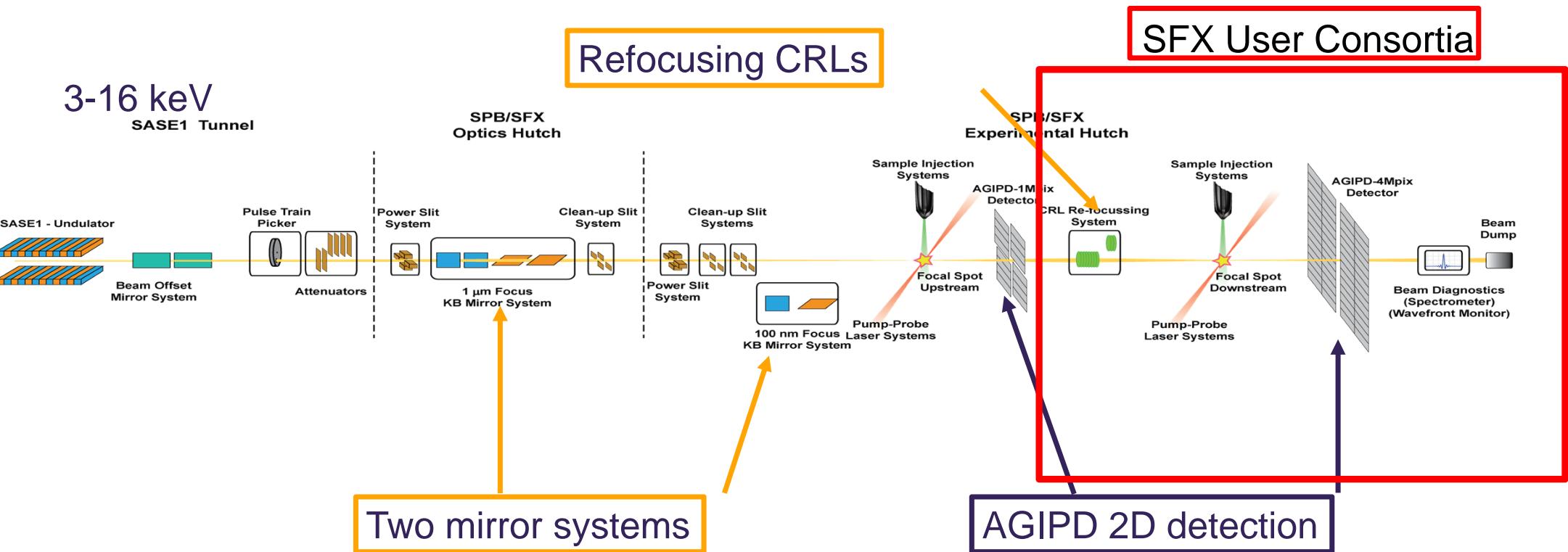


- 1st proposal round completed.
- 14 experiments were conducted.
- 2nd proposal round - 12 experiments – ended last week.
- 3rd proposal round evaluated 3 - 4 September
- Invitations to send out this week
- Call for proposal round 4 to be announced early November

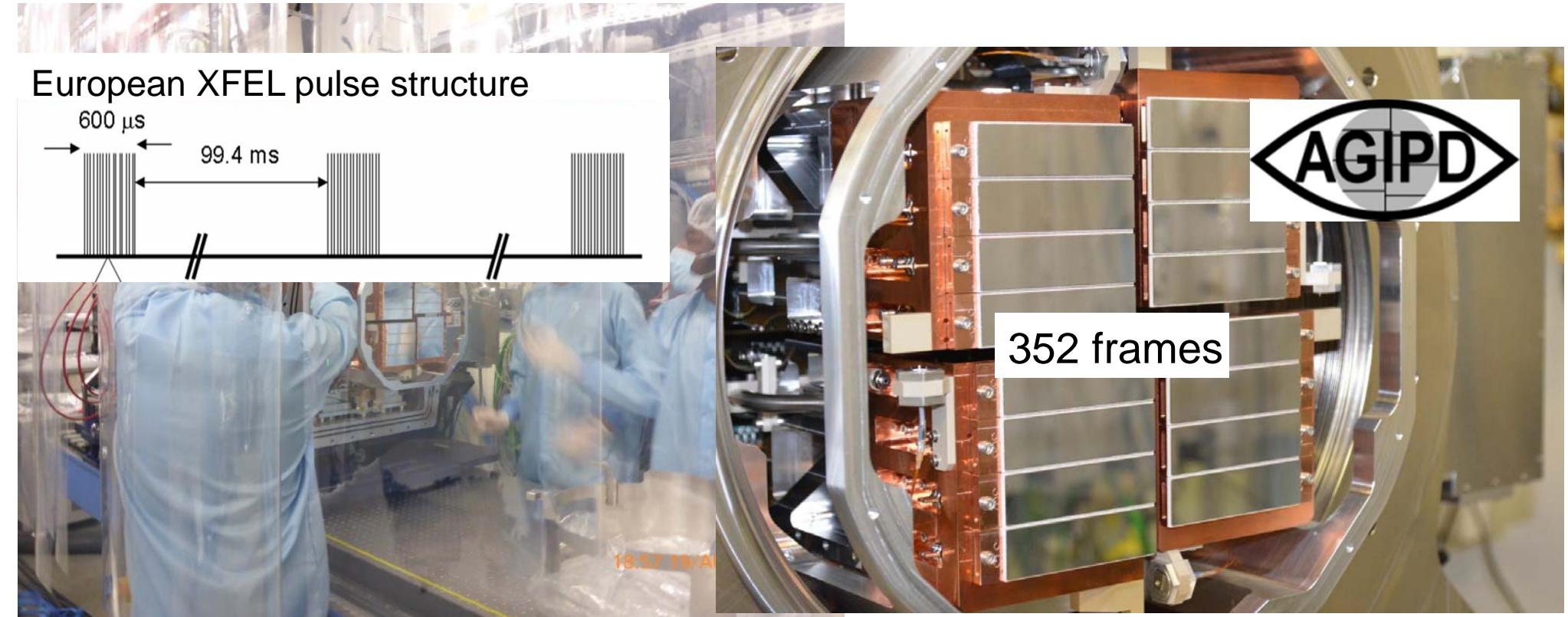
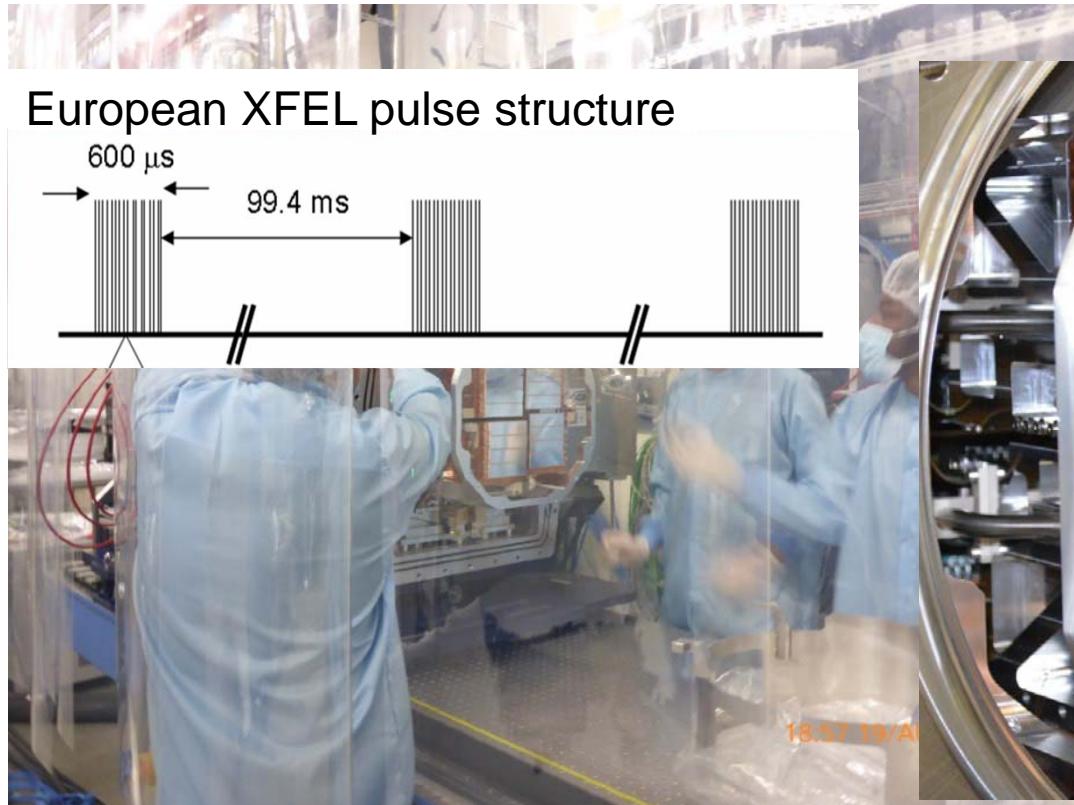


Four Months from first lasing to user operation !

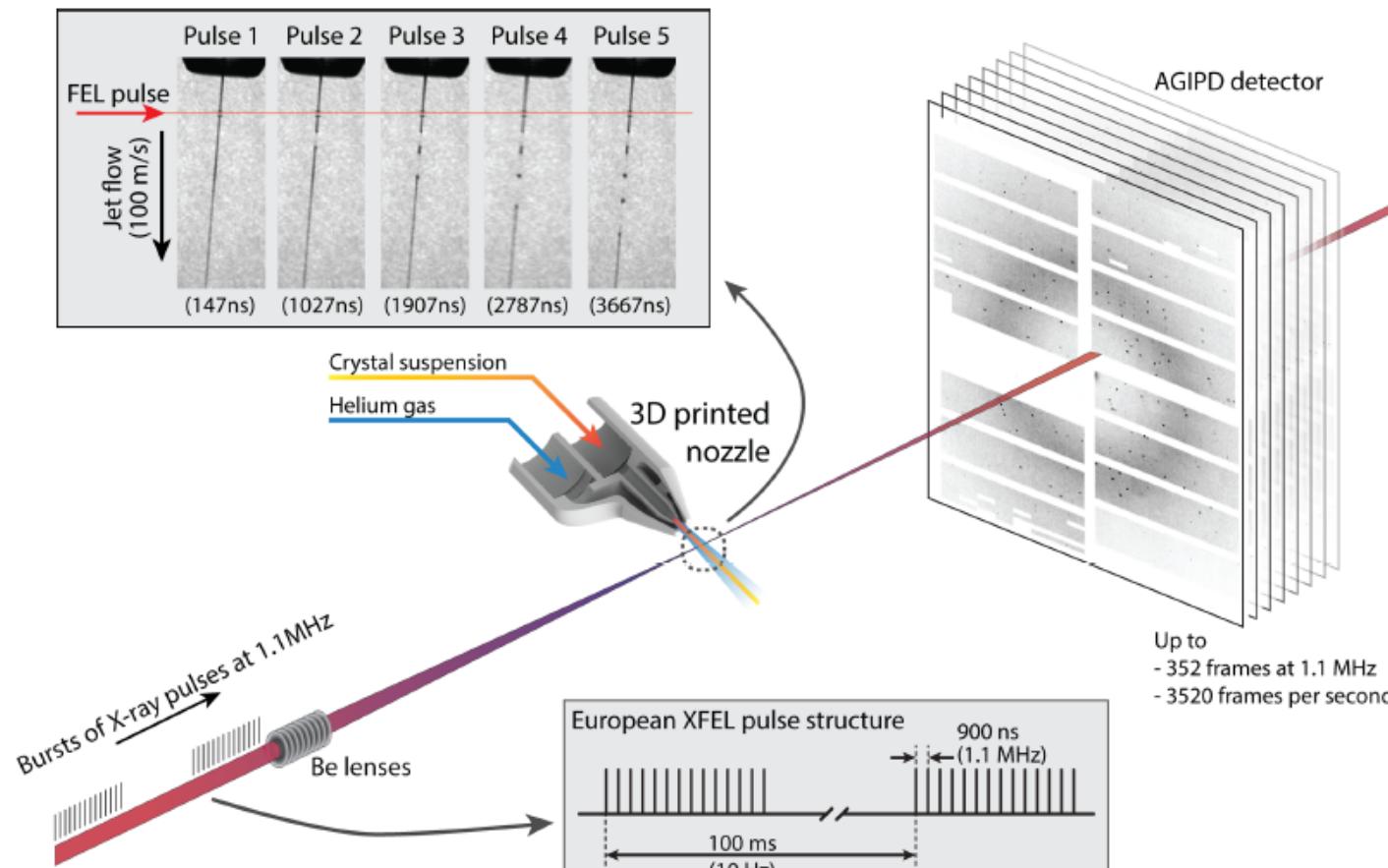
Schematic overview of the SPB/SFX Instrument



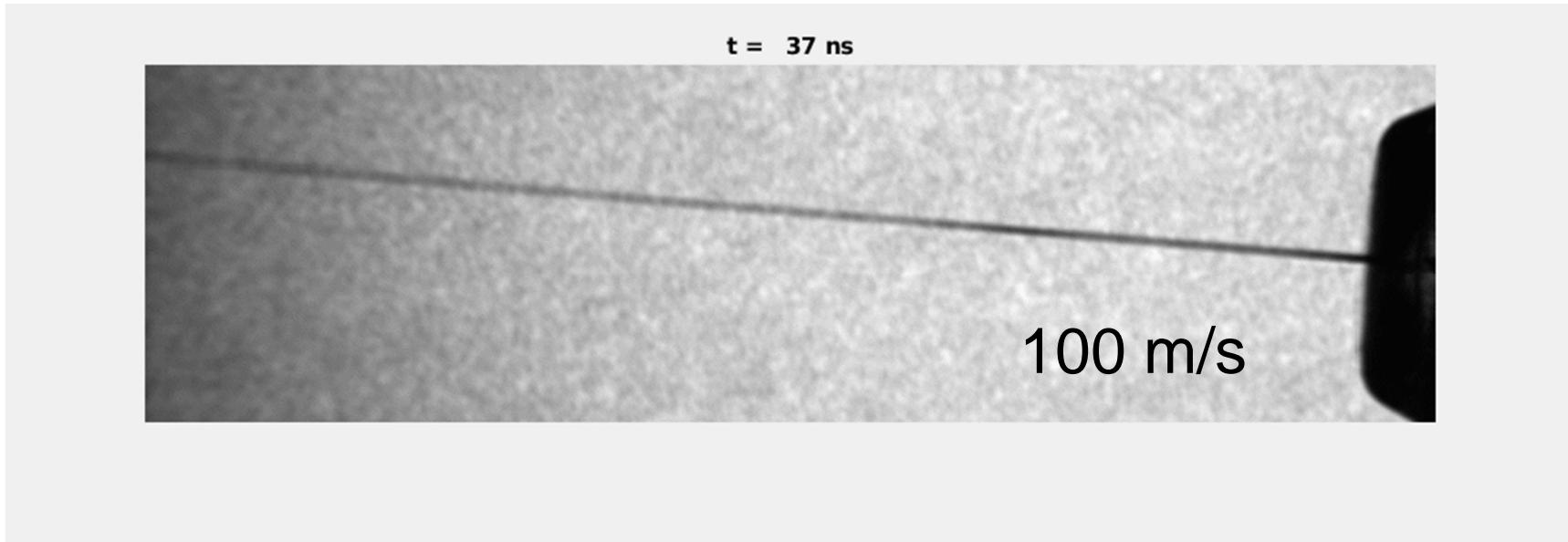
AGIPD Detector at SPB/SFX : Adaptive gain detector



Serial Femtosecond X-ray Crystallography



Fast jets recover in time for the next pulse at 1.1 MHz repetition rate



9.3 keV

580 mJ XFEL pulses

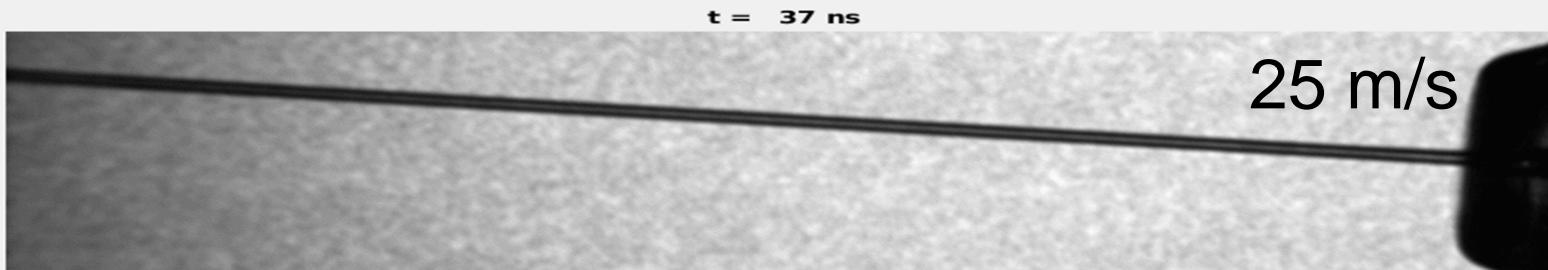
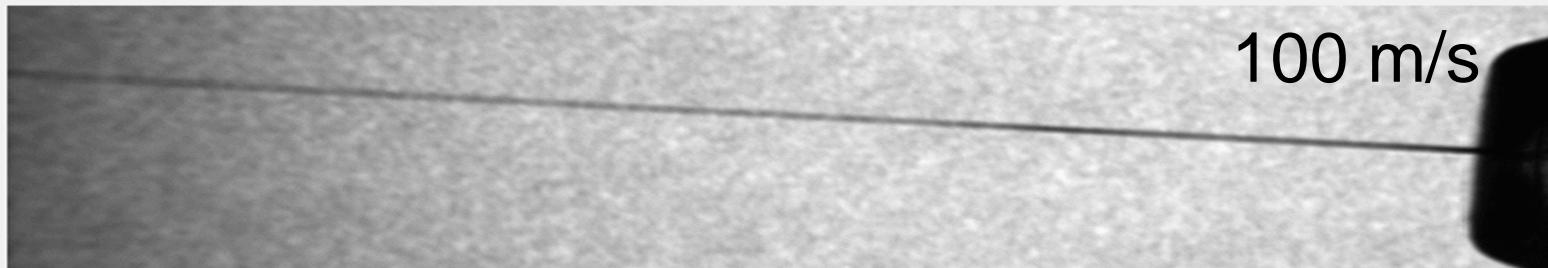
10 µm FWHM focus (or smaller)

1.1 MHz repetition rate



(courtesy A. Barty, H. Chapman)

CFEL-designed fast jets recover in time for the next pulse at 1.1 MHz repetition rate



Max Wierdorn, Claudio Stan

European XFEL

(courtesy A. Barty, H. Chapman)

SPB/SFX experiment #2012: Many thousands of frames of diffraction data was collected and successfully analysed to give a structure!

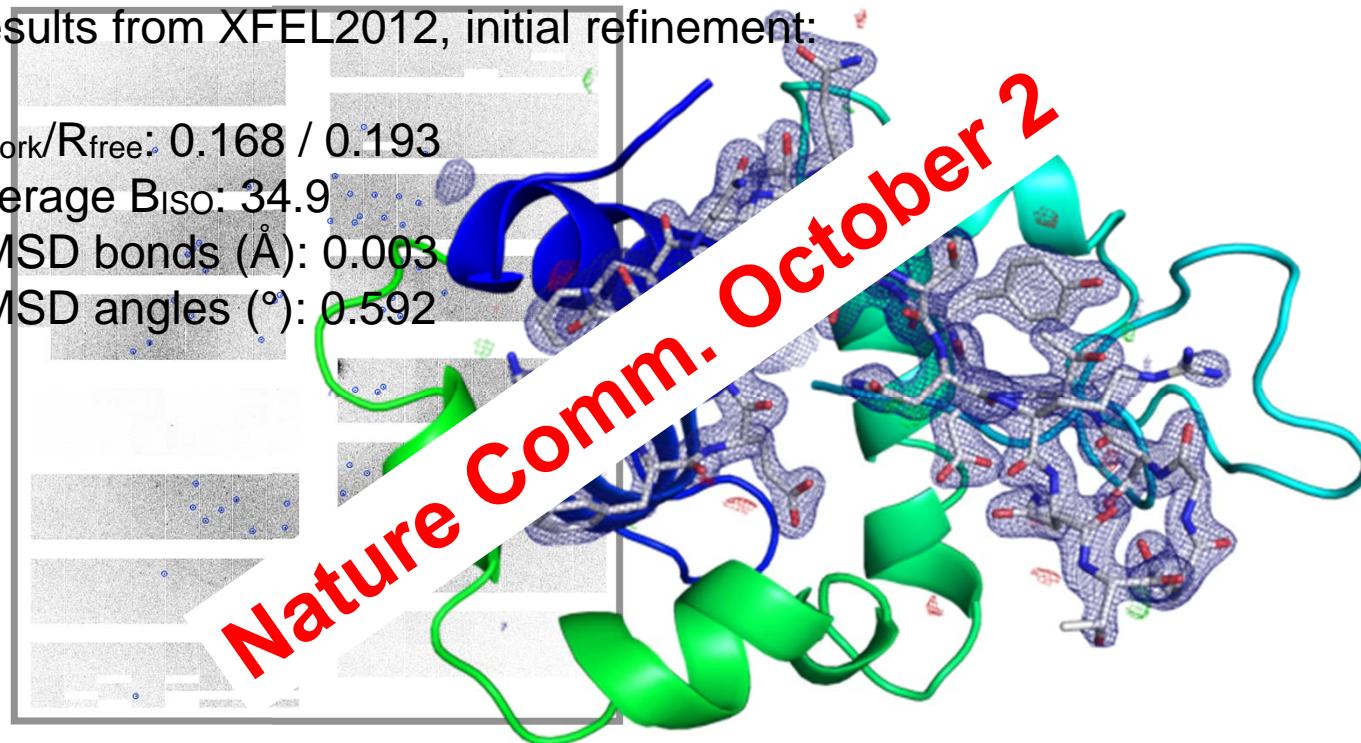
Results from XFEL2012, initial refinement:

R_{work}/R_{free} : 0.168 / 0.193

Average B_{iso} : 34.9

RMSD bonds (\AA): 0.003

RMSD angles ($^\circ$): 0.592

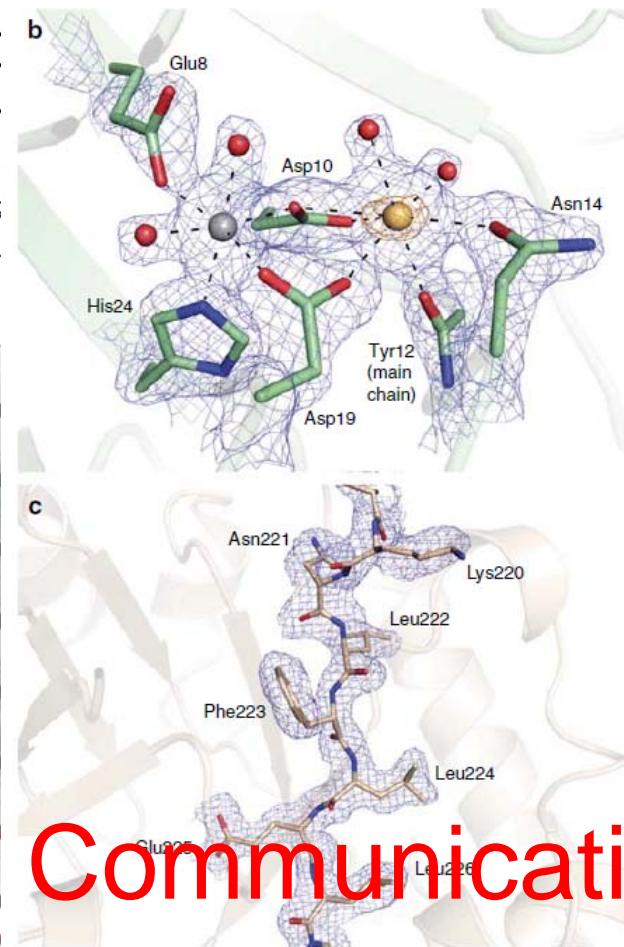
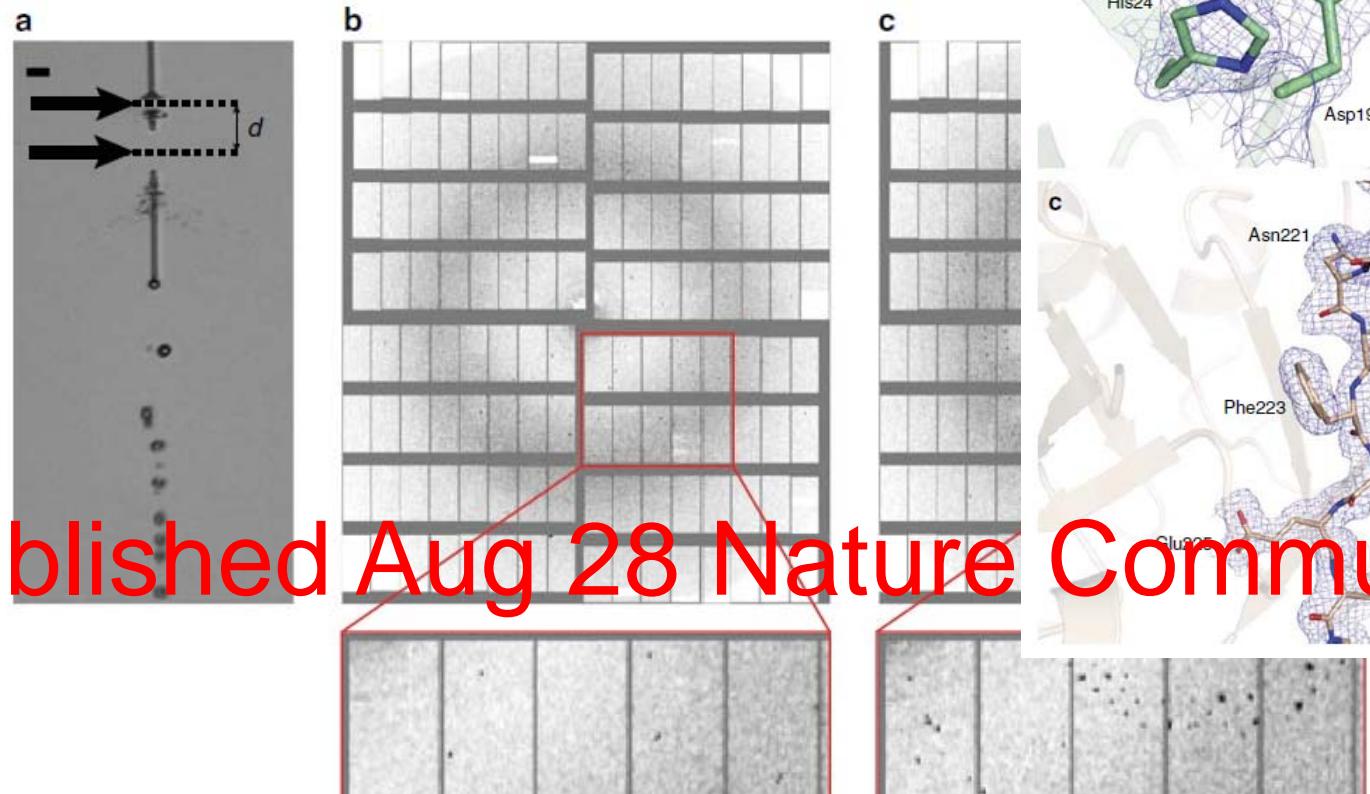


- This is the first realisation of the European XFEL's purpose—a complete experiment from start-to-end demonstrated in the very first user experiment at the facility at the SPB/SFX instrument (Data September 2017, Analysis November 2017). That is, structural biology works at XFEL!

Megahertz data collection from protein microcrystals at an X-ray free-electron

Marie Luise Grünbein¹, Johan Bielecki², Alexander Gorel¹, Miriam Stricker¹, Fabian Klock¹, Marco Cammarata^{1,3}, Katerina Dörner², Lars Fröhlich⁴, Elisabeth Hartmann¹, Michael Glaeser¹, Christian T. J. Räder¹, Daniel H. M. Müller¹, Robert Feidenhans'l¹

¹European XFEL GmbH, Hamburg, Germany; ²Institute of Physics, University of Regensburg, Regensburg, Germany; ³Department of Biochemistry, University of Regensburg, Regensburg, Germany; ⁴Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany



Published Aug 28 Nature Communication

XBI Bio Laboratories for Users



- 5-15 Users per SPB Beamtime (about 40 in total)
- Very positive feedback
- Usage:
 - Handling of cells
 - Dark room
 - Cold room
 - Anaerobic Box
 - Centrifugation
 - Cryogenic storage
 - Sample analysis
 - Microscopy
 - Growing crystals
 - Characterization
 - Preparation for injection

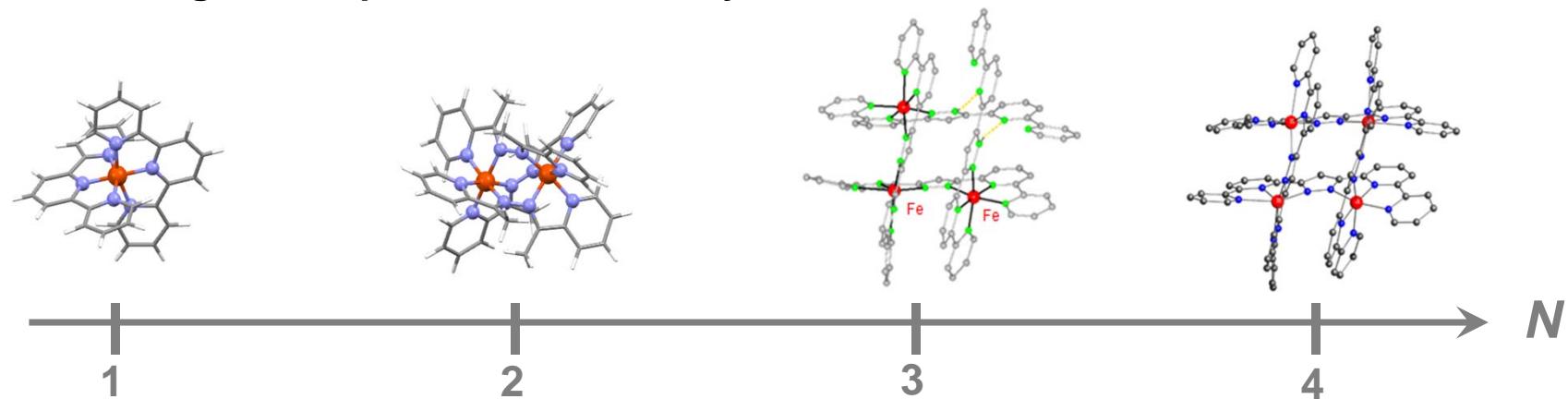
FXE scientific instrument (Christian Bressler)



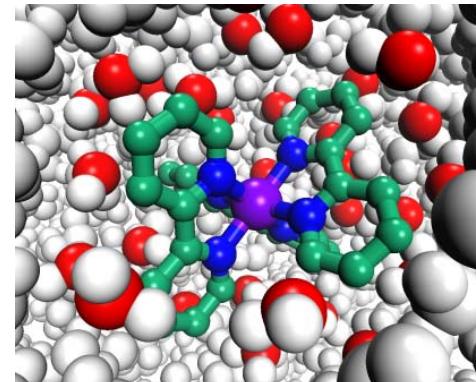
FXE : Controlling spin-state switching in the condensed phase (Experiment #2050)

30.11. – 04.12.2017 Sophie Canton (DESY/ELI)

■ Characterizing the **fs** spin and structural dynamics as function of N



■ What is the role of the solvation shell ?



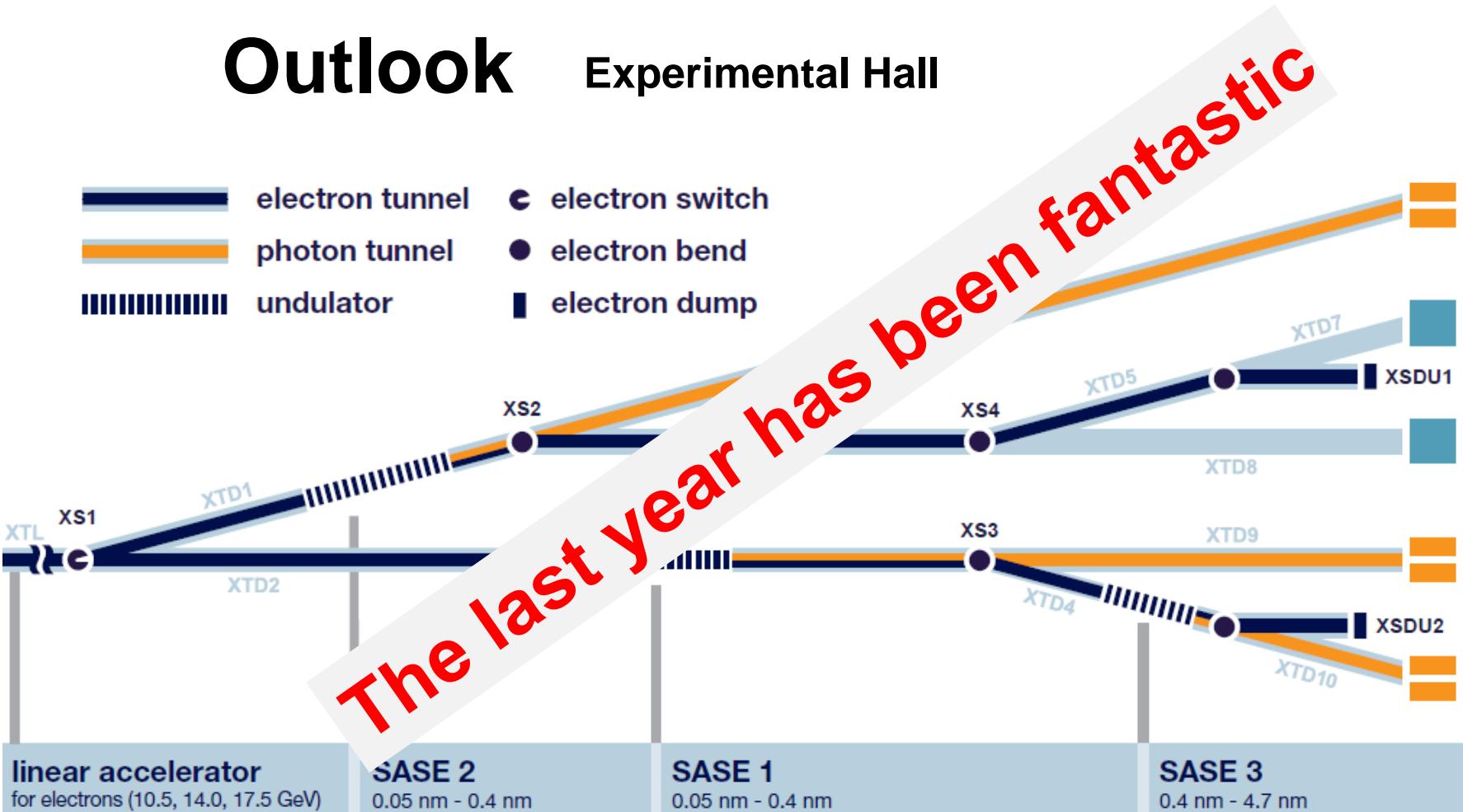
Implications

Molecular electronics, quantum information
Energy management in multichromophoric systems

Outlook Experimental Hall

-  electron tunnel
-  photon tunnel
-  undulator
-  electron switch
-  electron bend
-  electron dump

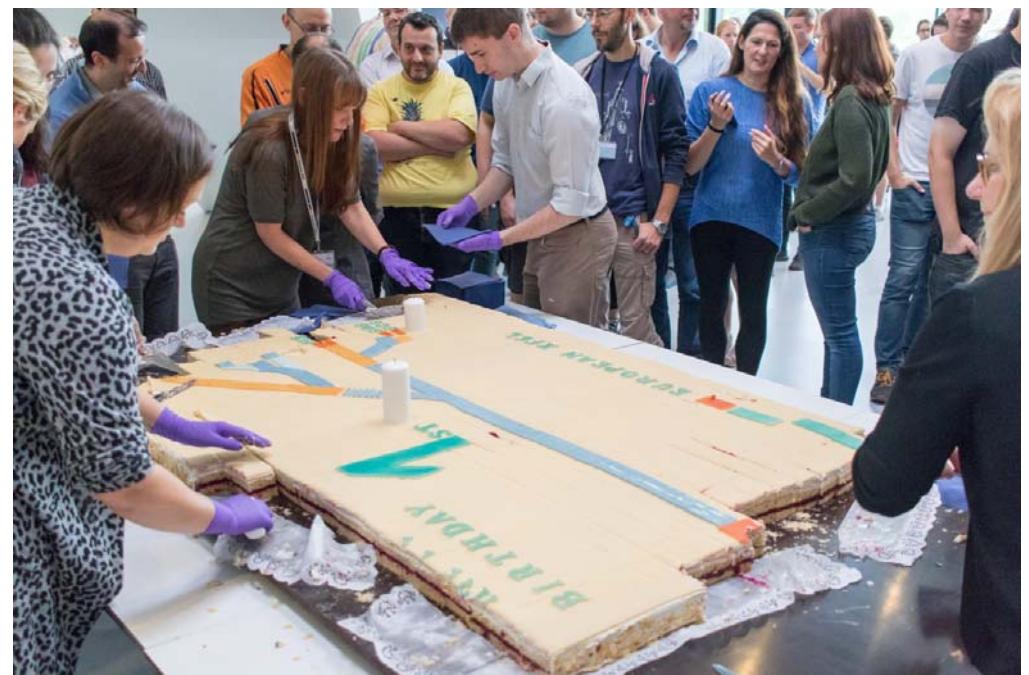
The last year has been fantastic



The diagram illustrates the layout of the European XFEL experimental hall. It starts with the linear accelerator (XTL) on the left, followed by the XTD1 undulator. The beam then splits into two main paths. The upper path contains the XS2 electron switch and electron bend, followed by the XTD5 undulator, which leads to the XTD7 photon tunnel and the XSDU1 electron dump. The lower path contains the XS3 electron switch and electron bend, followed by the XTD4 undulator, which leads to the XTD9 photon tunnel and the XSDU2 electron dump. The beam then rejoins at the XTD2 undulator, which leads to the SASE 2 source (0.05 nm - 0.4 nm). Further downstream are the SASE 1 (0.05 nm - 0.4 nm) and SASE 3 (0.4 nm - 4.7 nm) sources. The diagram also shows optional space for two undulators and four instruments.

HED	High Energy Density Science
MID	Materials Imaging and Dynamics
	Optional space for two undulators and four instruments
FXE	Femtosecond X-ray Experiments
SPB	Single Particles, Clusters, and Biomolecules and Serial Femtosecond Crystallography
SFX	Serial Femtosecond Crystallography
SQS	Small Quantum Systems
SCS	Spectroscopy & Coherent Scattering
XHEXP1	

Sep 5 : European XFEL celebrates one year of user operation

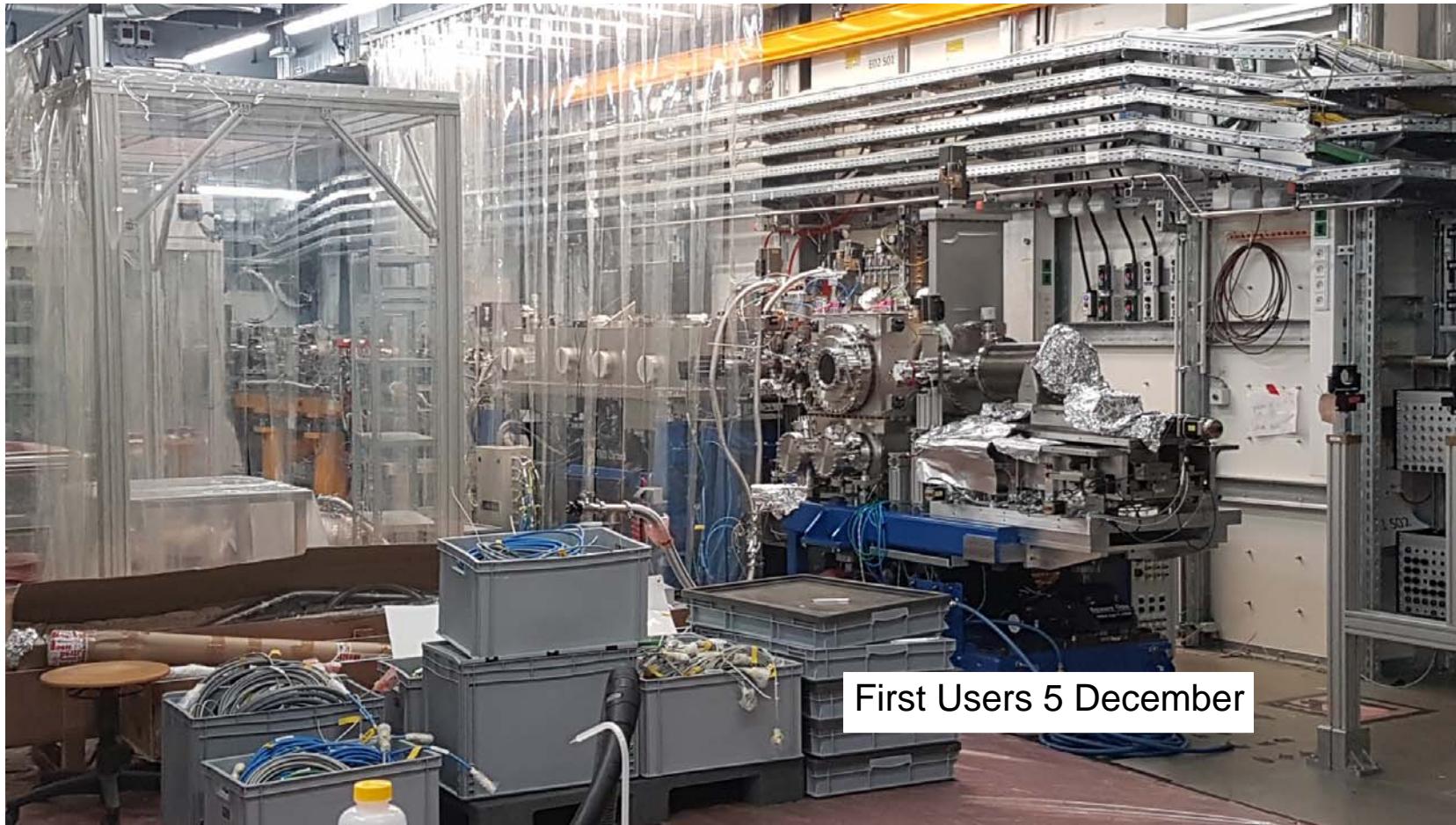


Progress SASE 2 and SASE 3

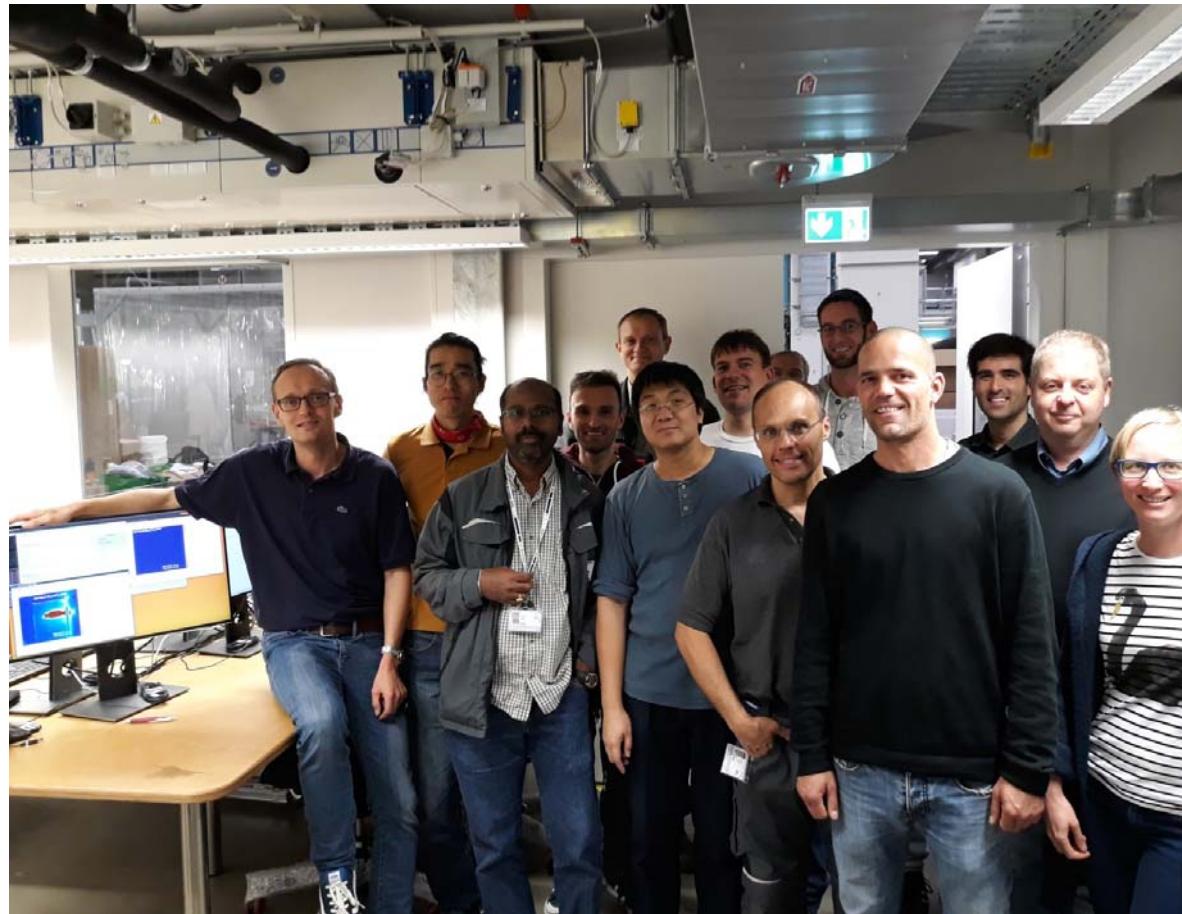
27.08.2018 – SQS experiment



27.08.2018 – SCS experiment



25 October – First Beam at MID



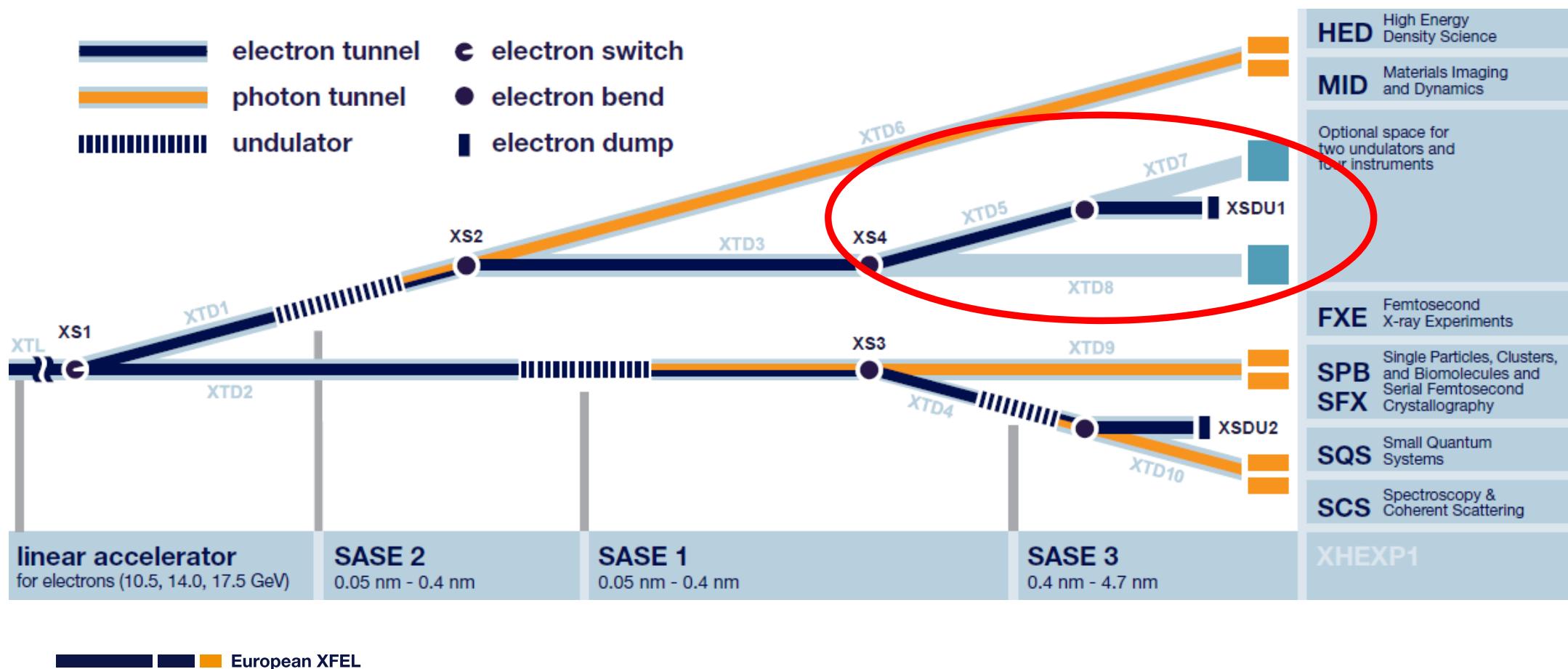
27.08.2018 – MID experiment



27.08.2018 – HED experiment



Experimental Hall



Shaping the Future : first workshop on Dec 6/7 options for the SASE4/5 tunnels

■ Day 1 : Session I : Introduction - Facility Description - Scientific trends

- A hard (7 keV - 25 keV) and ultra-hard X-ray source (25 keV -100 keV) for the European XFEL at 17.5 GeV
- Super-X: Simulations for super-hard X-ray generation with short period undulators for the European XFEL
- Hard X-ray generation at SHINE

■ Day 1: Session II : Hard X-rays

- A soft X-ray line for generating pulses between 1nm and a few 10s nm for the European XFEL
- External seeding possibilities at the European XFEL and THz addition
- Superradiance for Soft X-Ray production

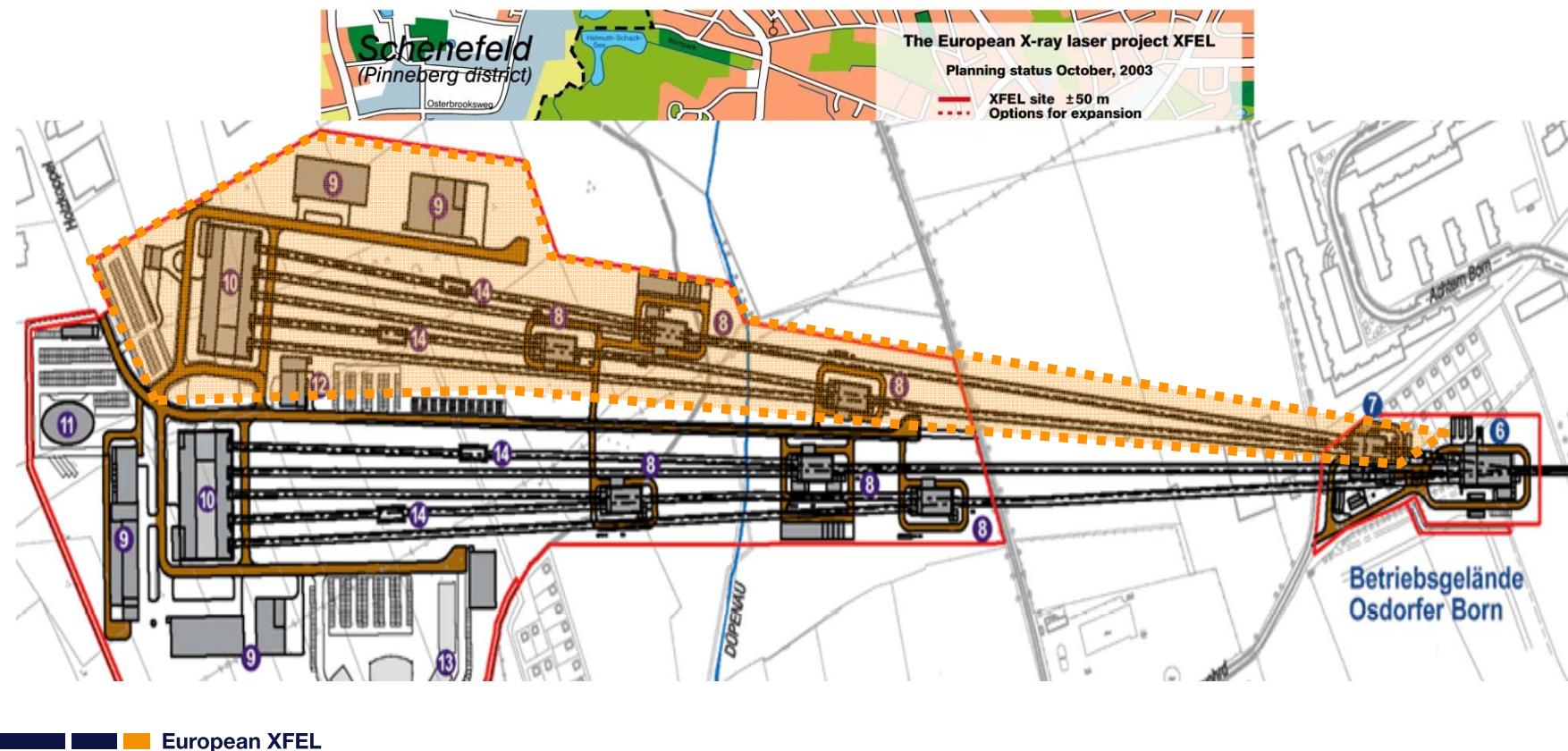
■ Day 2 : Session III: Soft X-Rays

- A soft X-ray line for generating pulses between 1nm and a few 10s nm for the European XFEL
- External seeding possibilities at the European XFEL and THz addition
- Superradiance for Soft X-Ray production

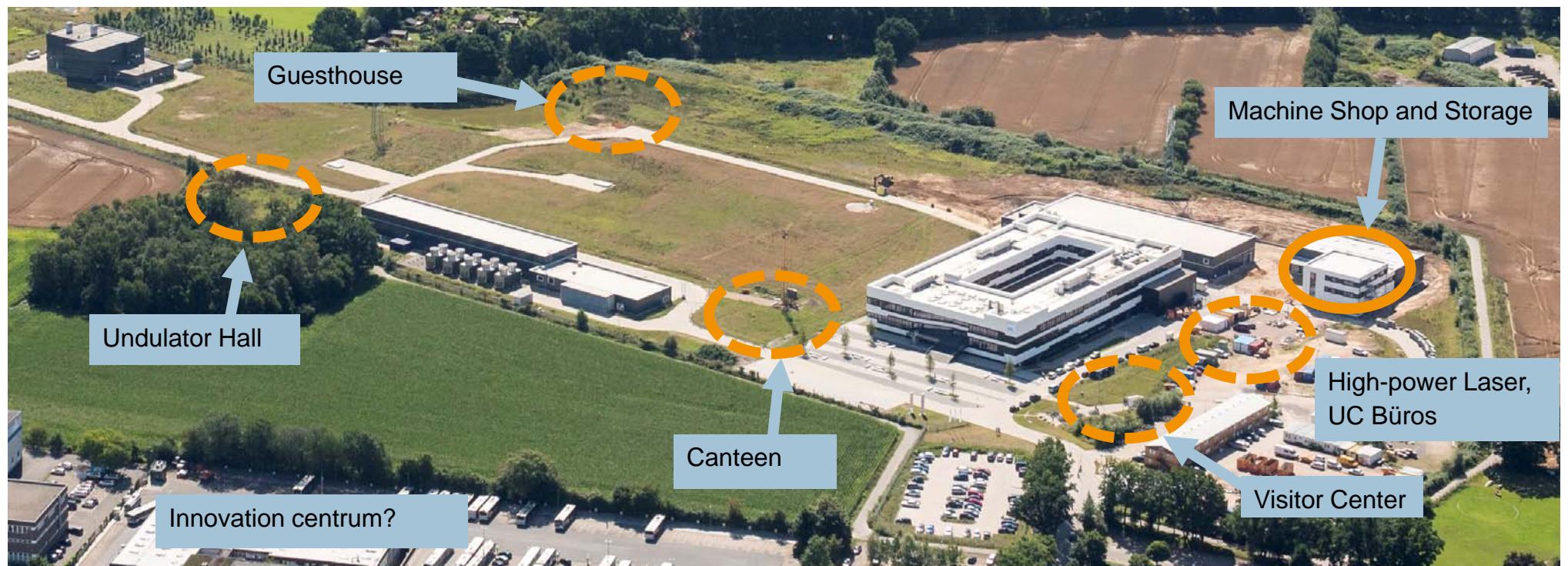


■ Session IV : Other concepts

■ Long term plan (~ 2027 - 2032) . Second fan and c.w.



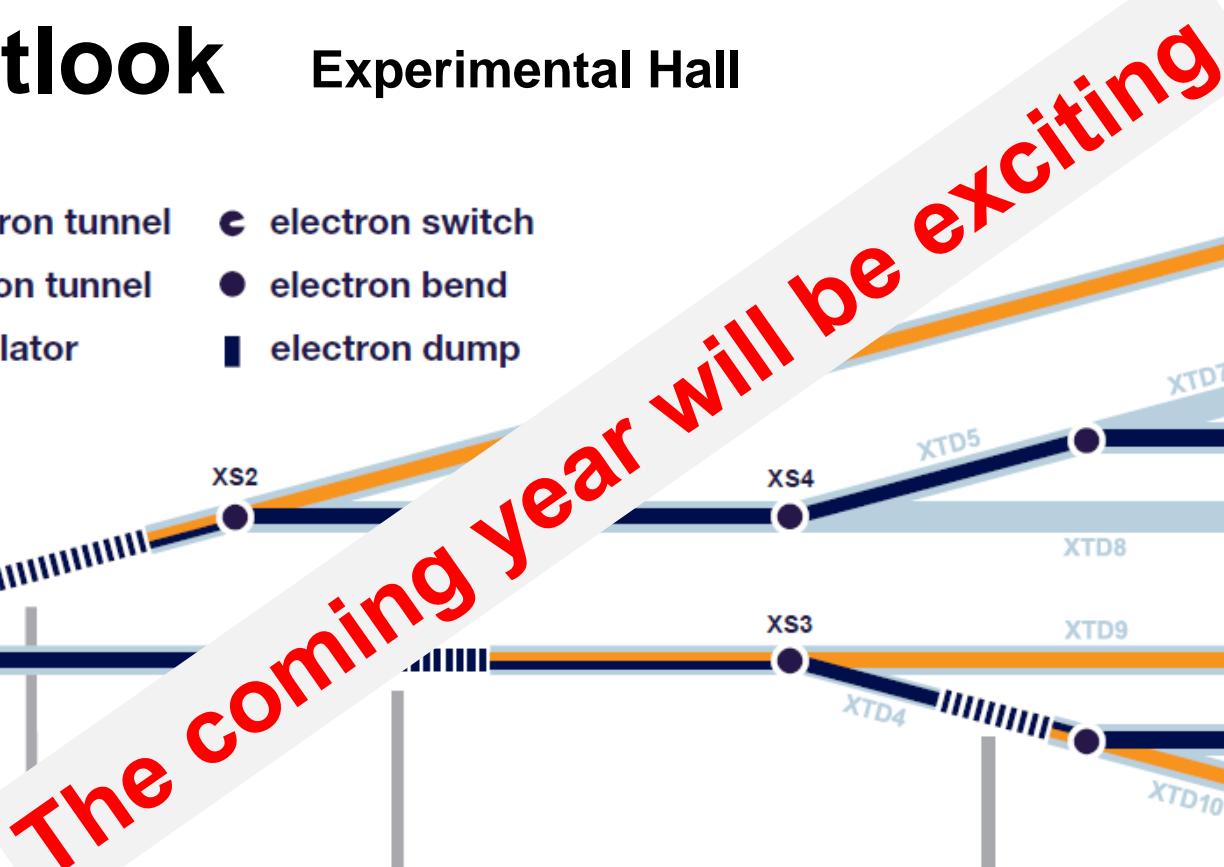
Campus Schenefeld including planned Canteen und Guesthouse



Outlook Experimental Hall

-  electron tunnel
-  photon tunnel
-  undulator
-  electron switch
-  electron bend
-  electron dump

The coming year will be exciting



linear accelerator
for electrons (10.5, 14.0, 17.5 GeV)

SASE 2
0.05 nm - 0.4 nm

SASE 1
0.05 nm - 0.4 nm

SASE 3
0.4 nm - 4.7 nm

HED	High Energy Density Science
MID	Materials Imaging and Dynamics
	Optional space for two undulators and four instruments
FXE	Femtosecond X-ray Experiments
SPB	Single Particles, Clusters, and Biomolecules and Serial Femtosecond Crystallography
SFX	Serial Femtosecond Crystallography
SQS	Small Quantum Systems
SCS	Spectroscopy & Coherent Scattering
XHEXP1	

Acknowledgement to the fantastic staff at European XFEL



And to the fantastic Accelerator Staff



**Thanks to all the DESY accelerator staff for their
hard work and for their commitment**