



# The European X-Ray Free-Electron Laser: General Status of the Project

Massimo Altarelli

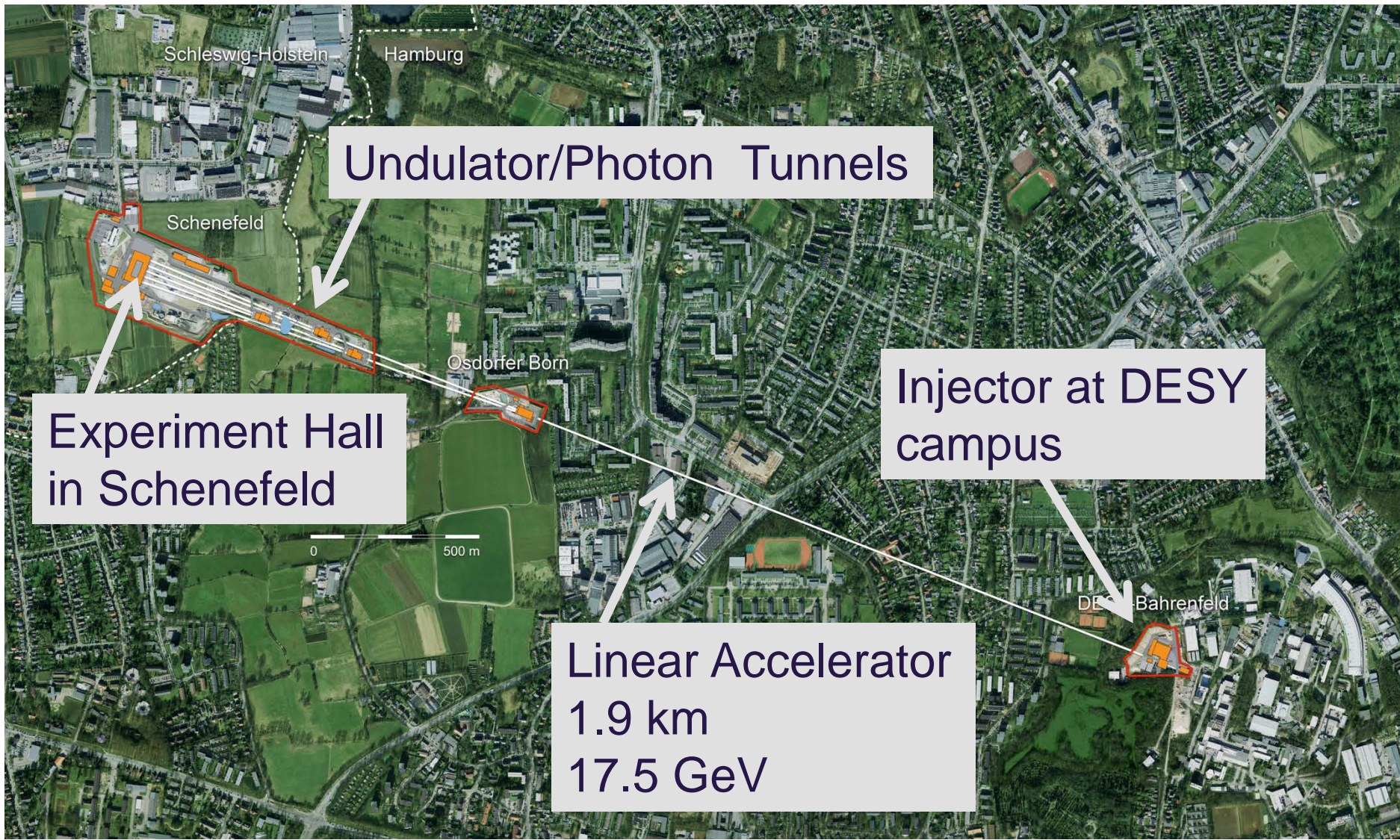
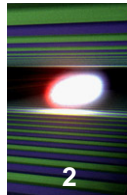
*on behalf of the Management Board*

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22761 Hamburg, Germany*

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# European XFEL layout

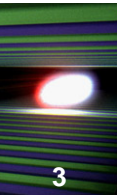


Undulator/Photon Tunnels

Experiment Hall  
in Schenefeld

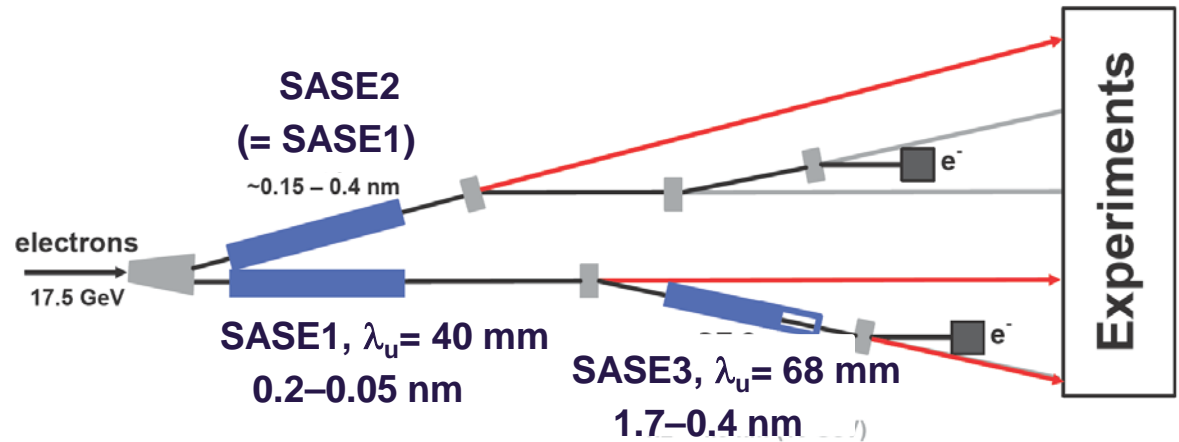
Injector at DESY  
campus

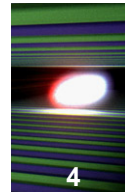
Linear Accelerator  
1.9 km  
17.5 GeV



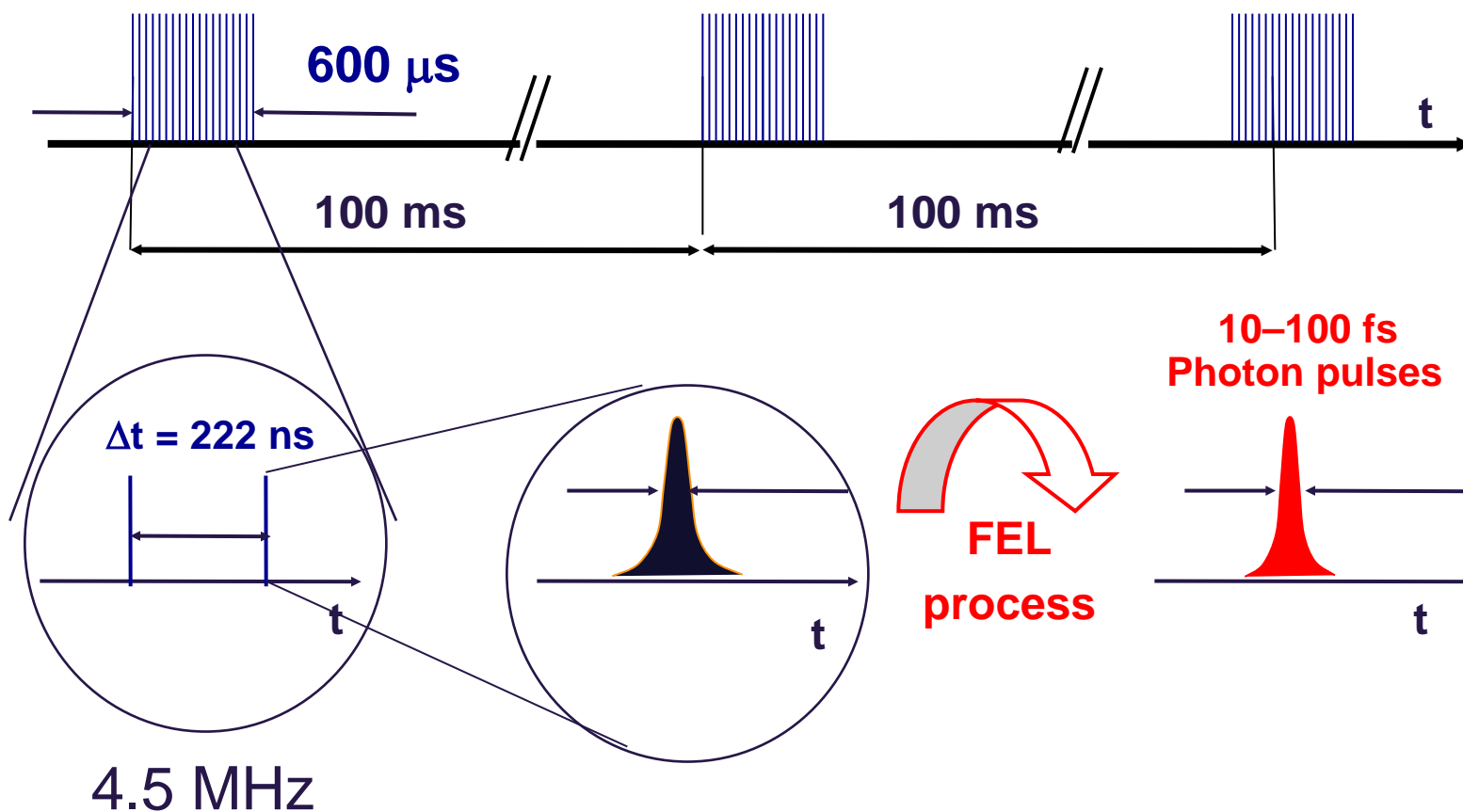
## Some specifications

- Photon energy 0.24– >24 keV
- Pulse duration ~ 10–100 fs
- Pulse energy few mJ
- Superconducting linac. 17.5 GeV
- 10 Hz (27 000 b/s)
- 5 beamlines / 10 instruments
  - Start version with 3 BLs and 6 instruments
- Several extensions possible:
  - More undulators
  - More instruments
  - .....
  - Self-Seeding
  - CW operation

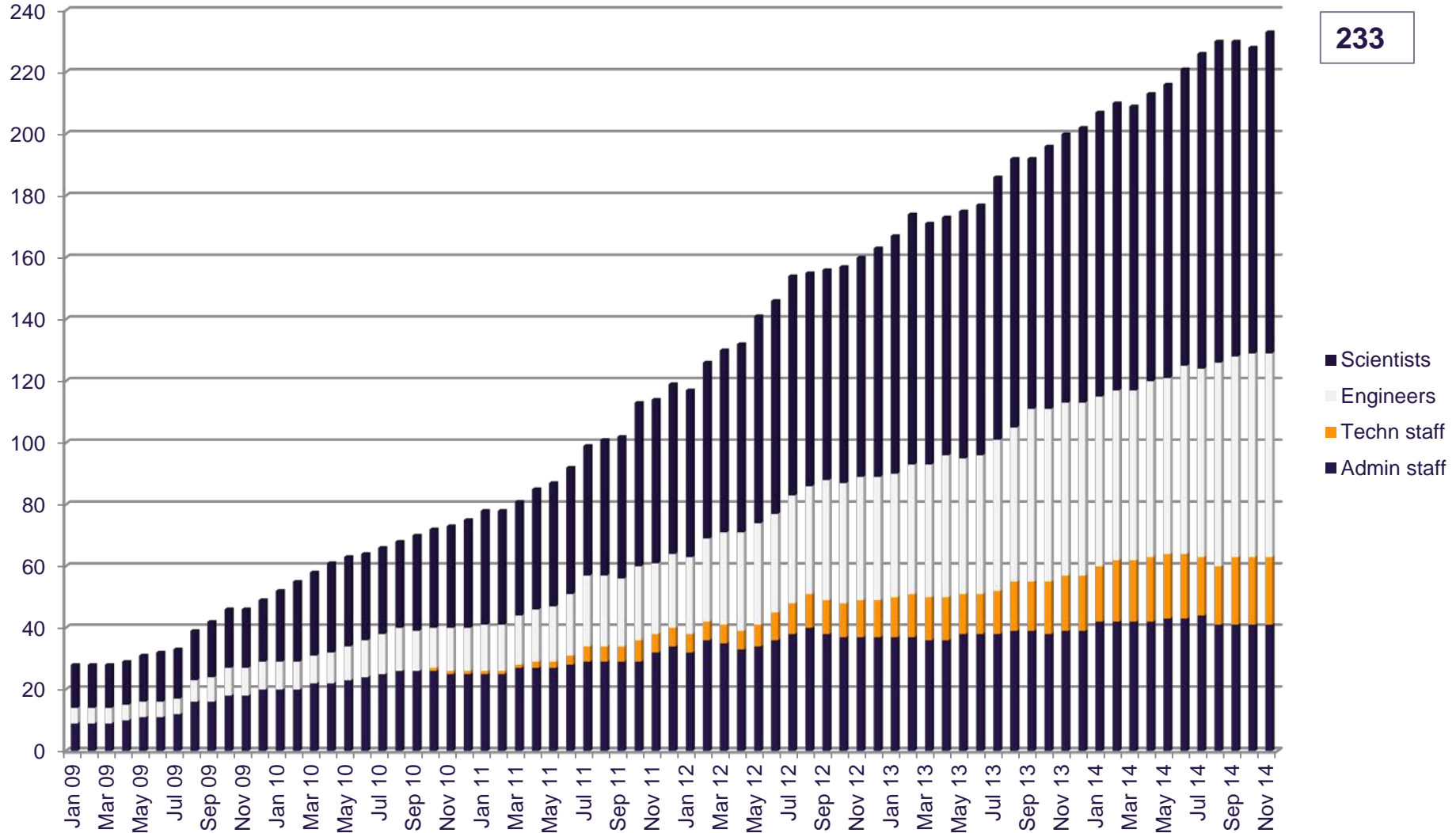
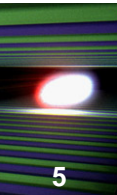




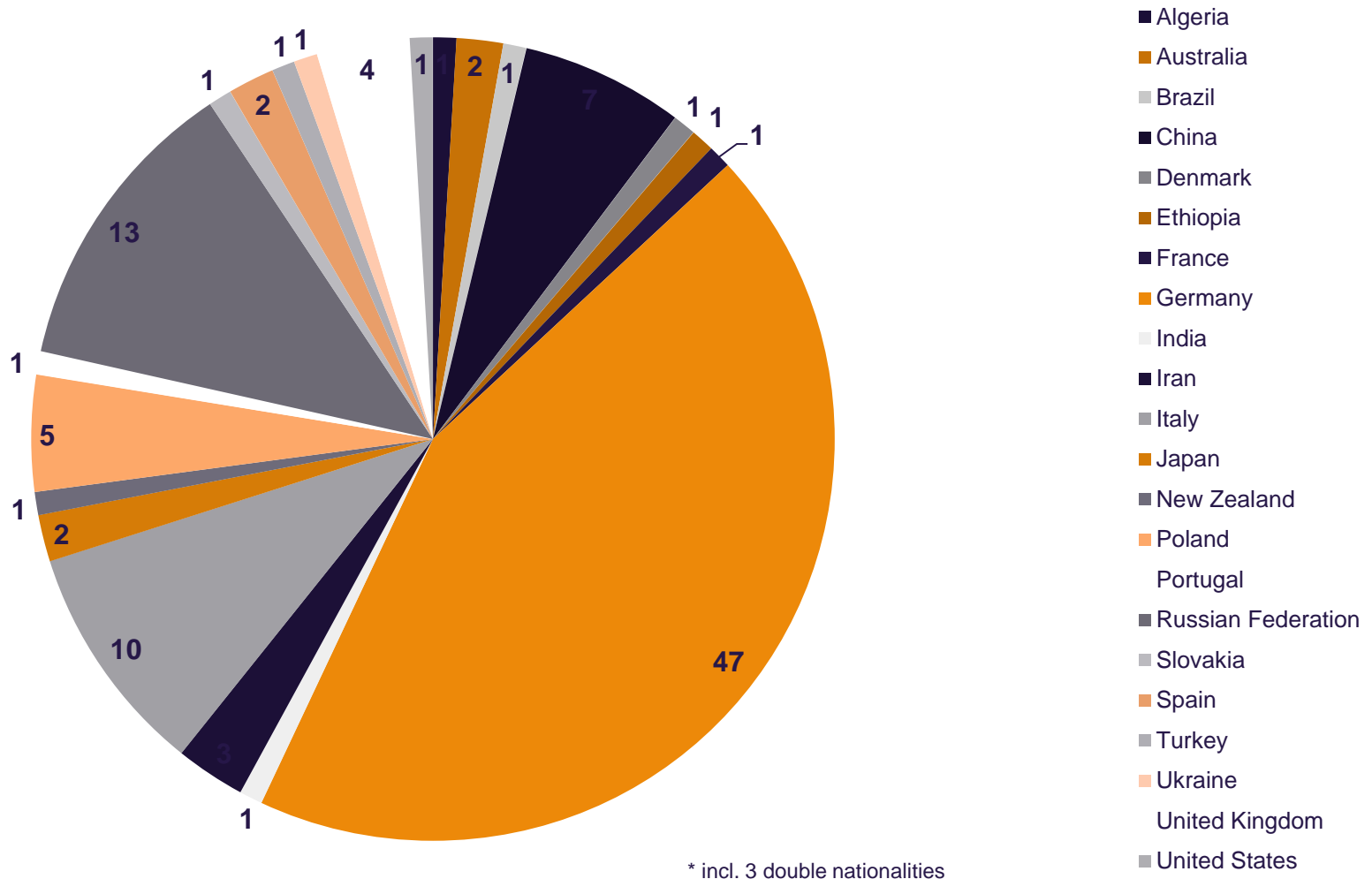
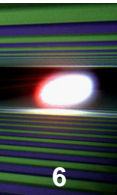
## Electron bunch trains (with up to 2700 bunches, 0.1–1 nC)



# Staff Development (including guests)

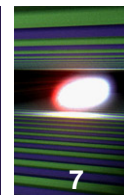


# Nationalities Scientific Staff\*



German 44%  
International 57%  
22 Nationalities

\* incl. 3 double nationalities

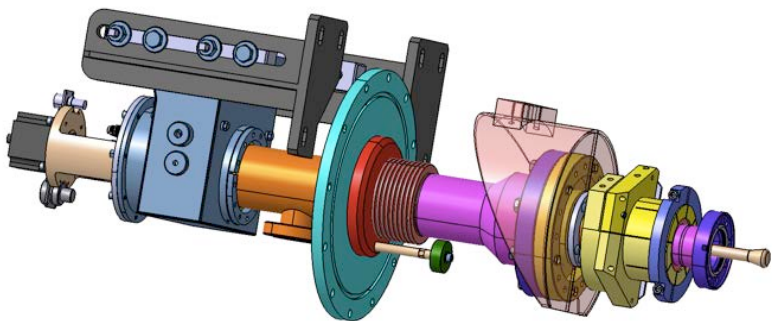


<b>WHEN</b>	<b>MILESTONE</b>
<b>30 June 2015</b>	<b>Injector Tunnel closed</b>
<b>31 January 2016</b>	<b>SASE1 experimental area ready for instrument (FXE, SPB/SFX) installation</b>
<b>31 May 2016</b>	<b>SASE3 experimental area ready for instrument (SCS, SQS) installation</b>
<b>30 June 2016</b>	<b>Linac tunnel closed</b>
<b>31 December 2016</b>	<b>First SASE1 lasing possible</b>
<b>30 April 2017</b>	<b>SASE1 instruments begin operation</b>

# Main risks to the general schedule

- Problems with mass production and integration of a few crucial linear accelerator components  
(See presentation by Hans Weise)
- In June 2014, the Council “authorized the Management Board to take all necessary and appropriate measures within the overall budget constraints to accelerate the module assembly in order to ensure the common goal of tunnel closing by mid- 2016 and first SASE1 lasing by the end of 2016”

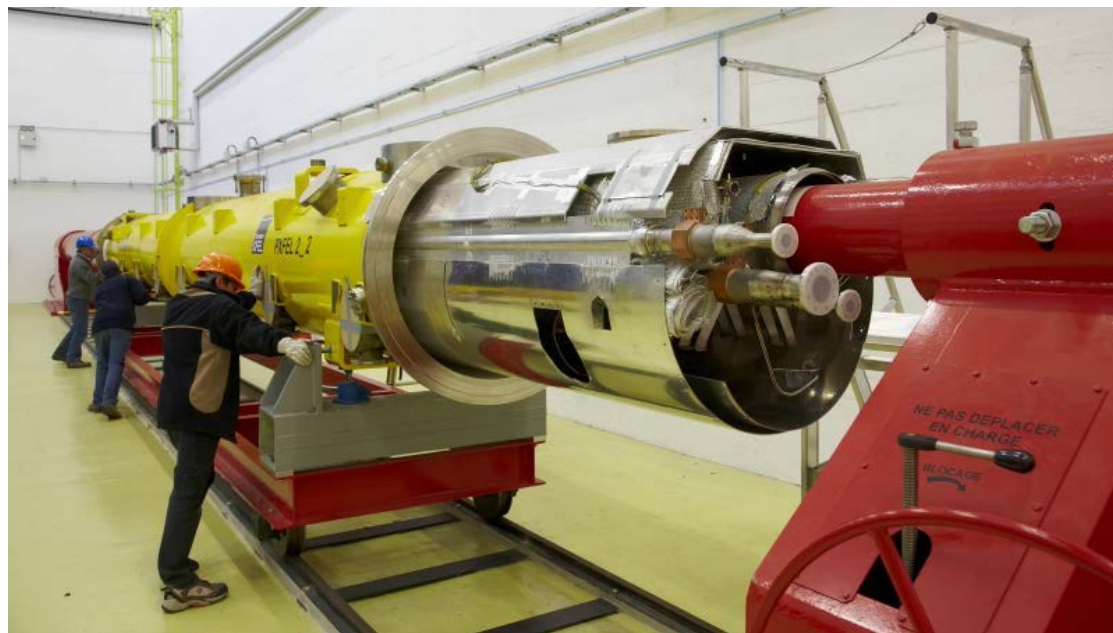


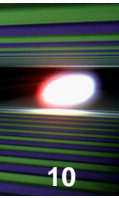


RF Couplers: Actions to increase yield of in-kind contribution; besides 150 couplers ordered from alternative industrial supplier.

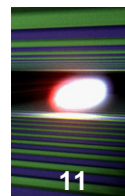
## Module Assembly:

Actions and investments to achieve and consolidate assembly rate from September 2014 on, and to further increase assembly rate from early 2015

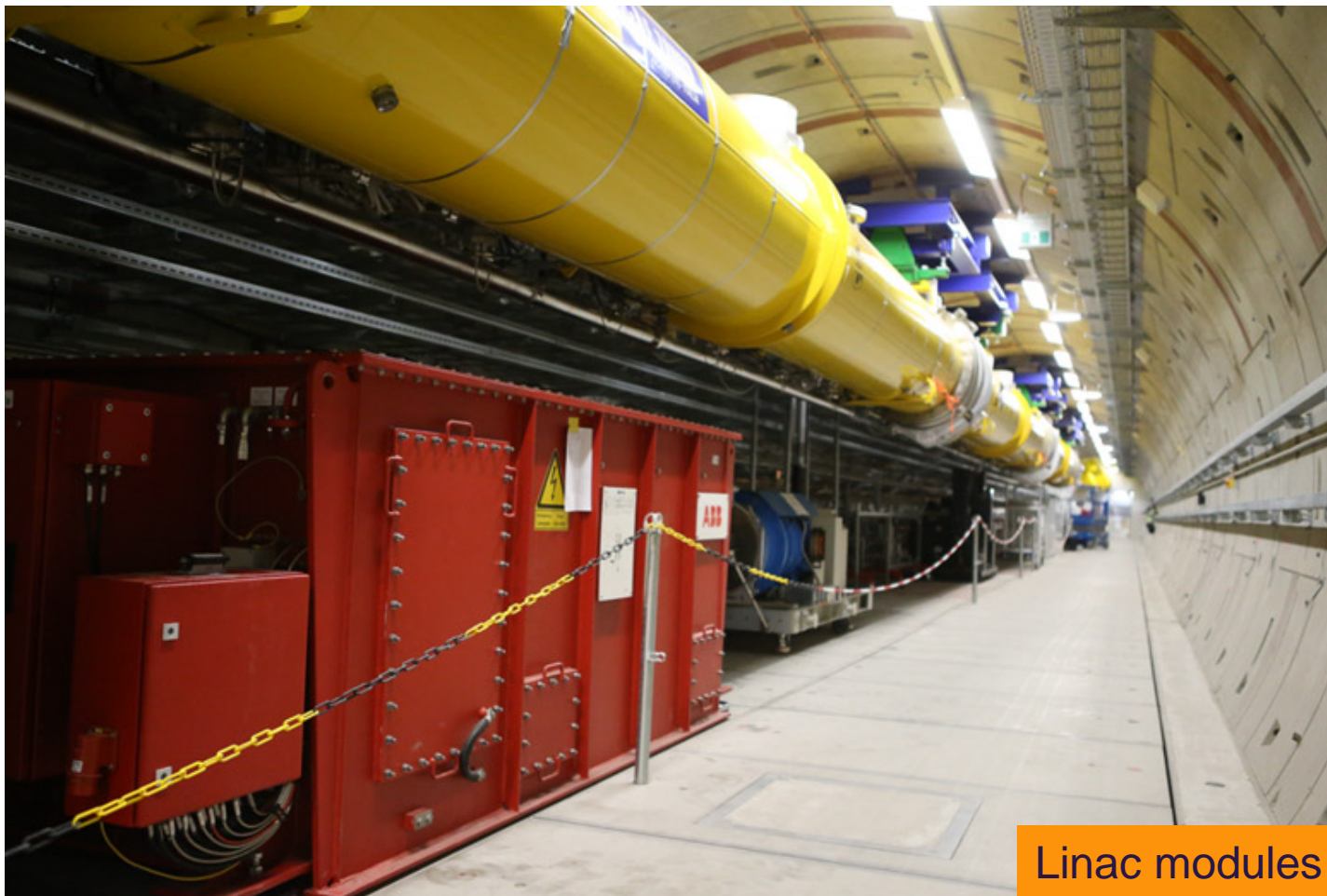




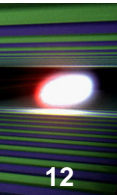
- Consolidate and accelerate not only assembly but also testing and installation schedule of modules, to confirm closure of linac tunnel in mid 2016
- Follow up other issues in other parts of the project that may come close to the critical path



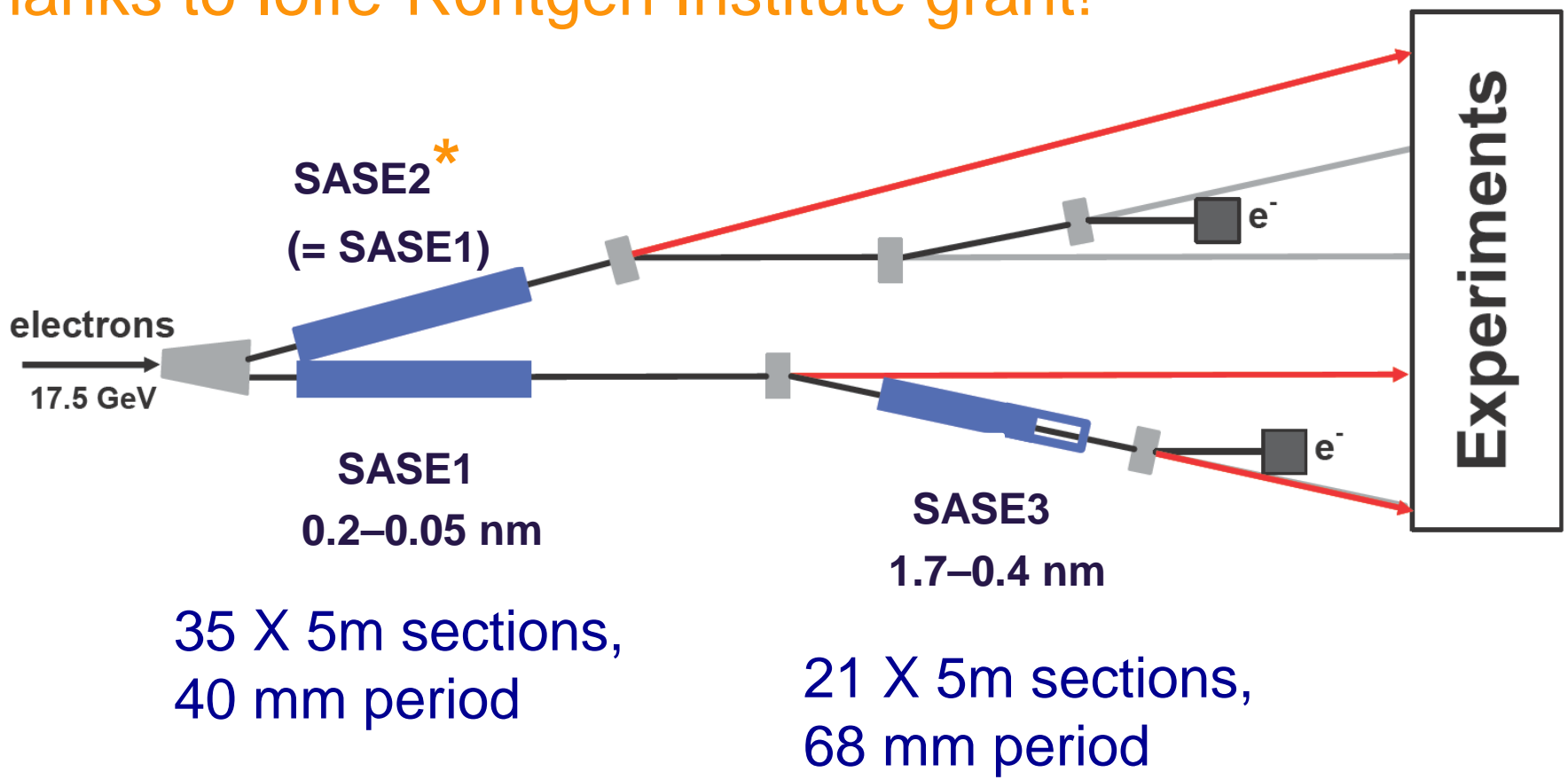
- Linac installation work started (See presentation H. Weise)

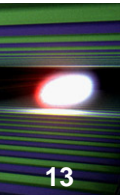


Linac modules



**\*NEW!** : Shall be equipped for self-seeding,  
thanks to Ioffe-Röntgen Institute grant!

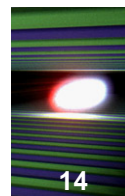




## ■ Preparing for installation



## SASE 1 undulator tunnel

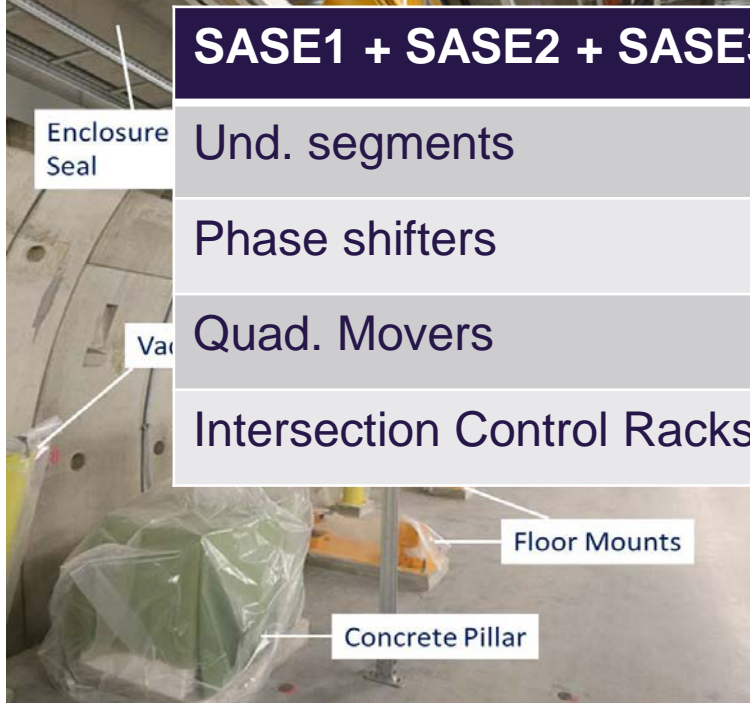


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Undulator Control

- Installation complete by late 2015
- SASE3 is next, following about 5 months later

Enclosure  
Seal

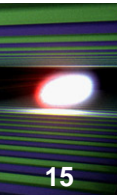
Val

Floor Mounts

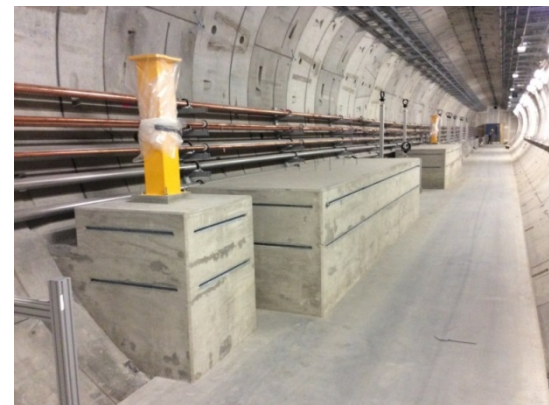
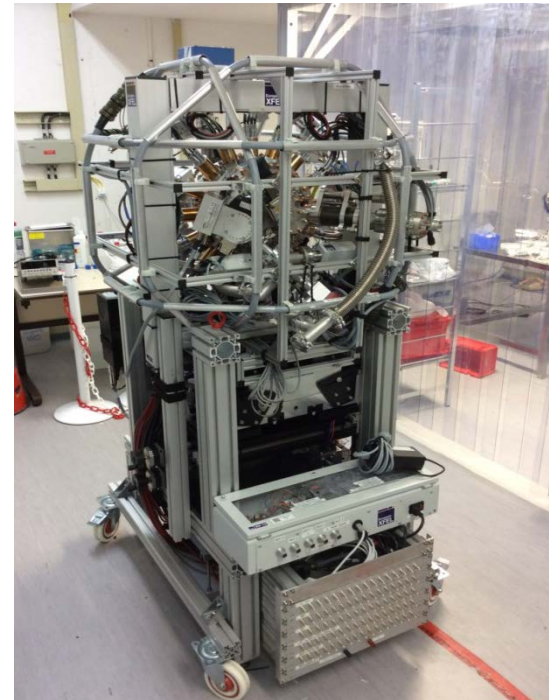
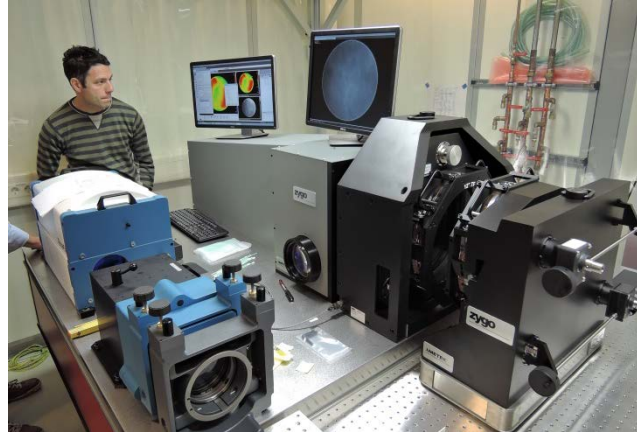
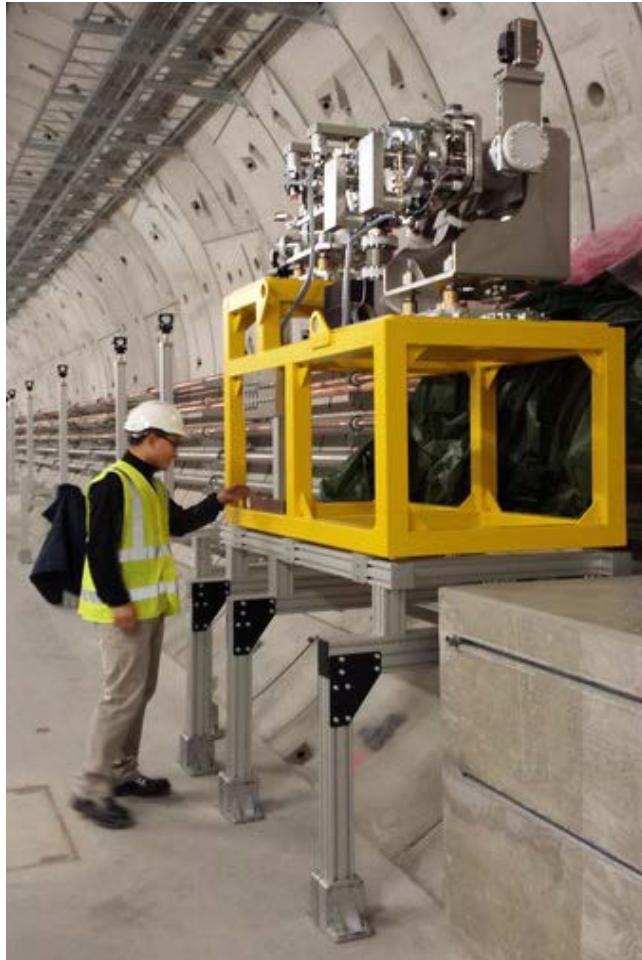
Concrete Pillar

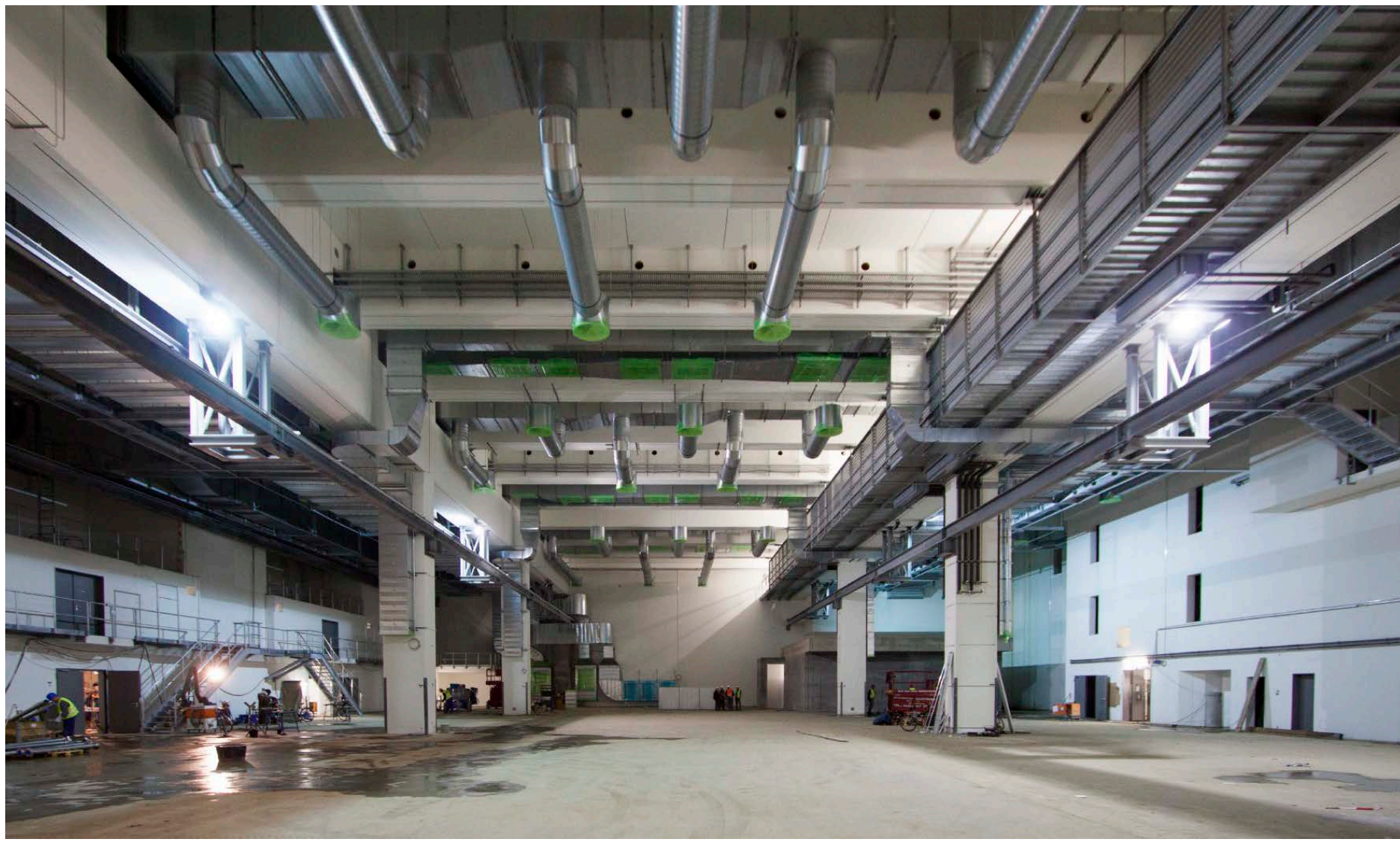
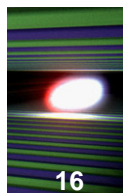
SASE1 + SASE2 + SASE3	Needed	FAT passed	SAT passed
Und. segments	91	91	83
Phase shifters	91	70	56 (= 35 + 21)
Quad. Movers	91	84	80
Intersection Control Racks	91	91	91

- J. Pflüger, WP71

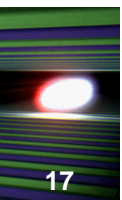


- See presentation by Harald Sinn

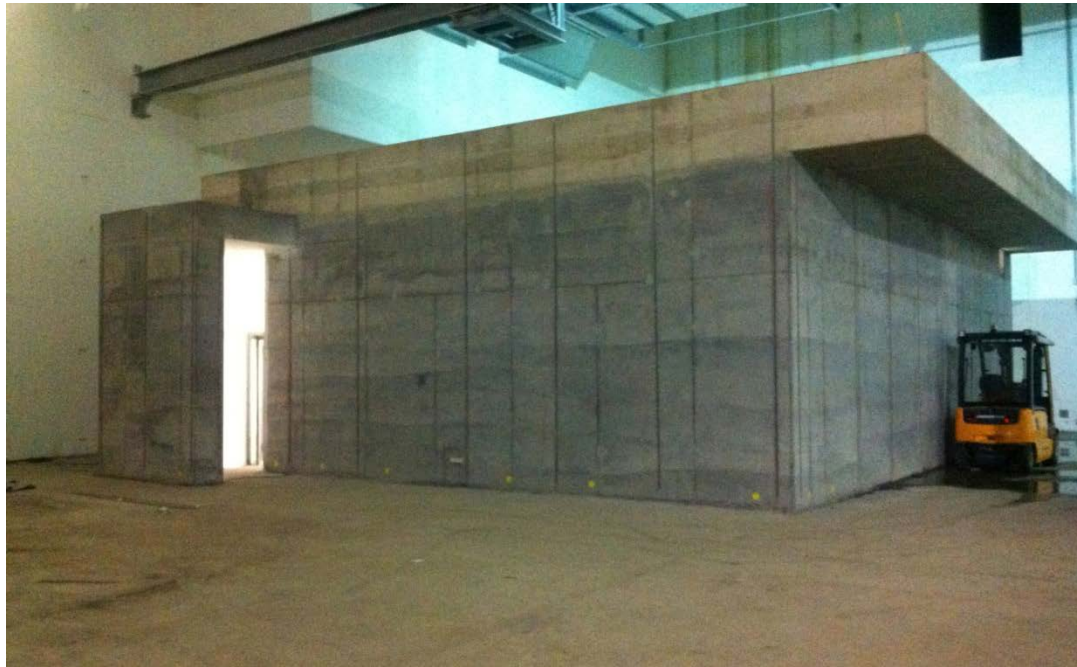








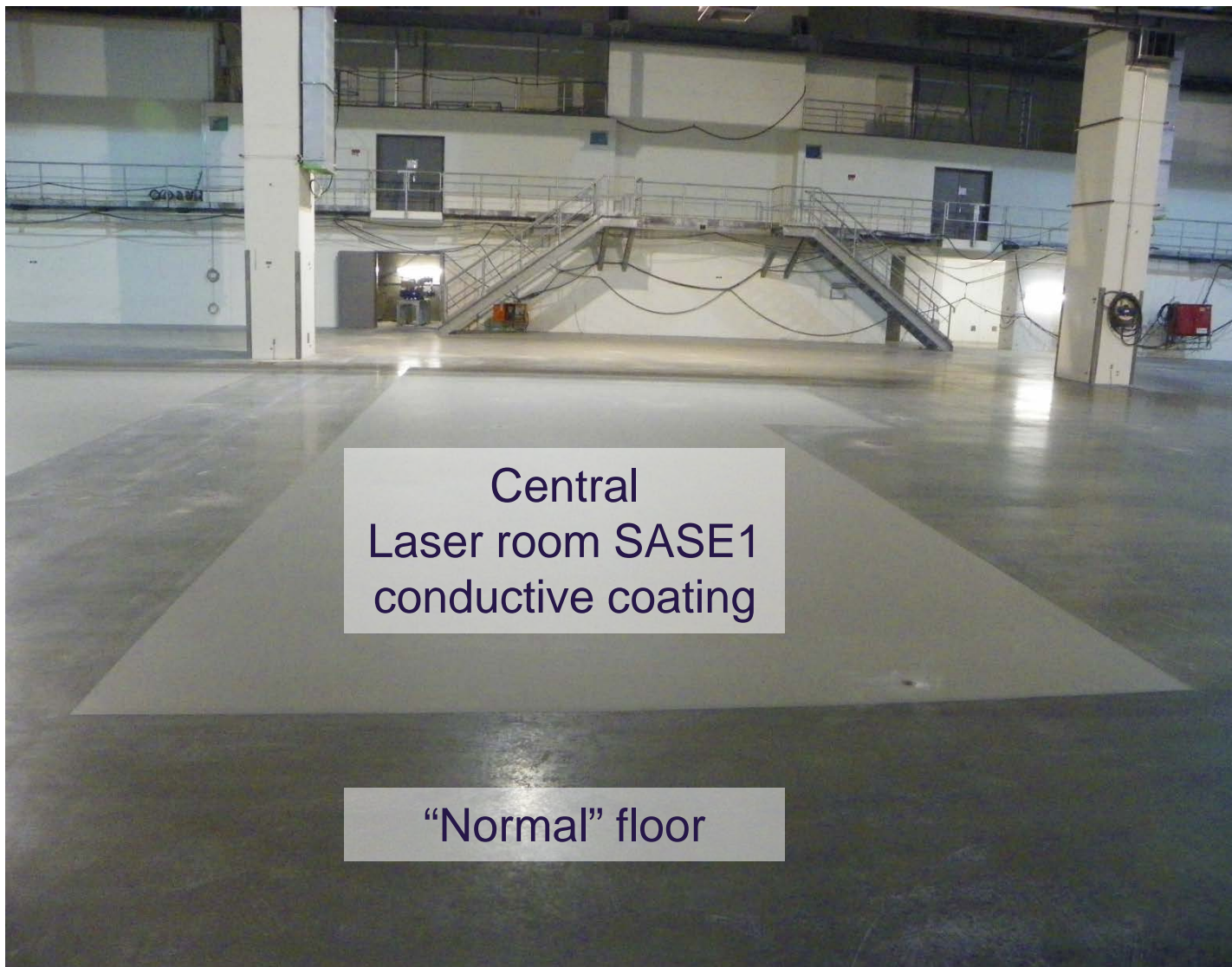
- HED experiments enclosure completed



- Too heavy to build after final floor coating



# Floor coatings and preparations



Central  
Laser room SASE1  
conductive coating

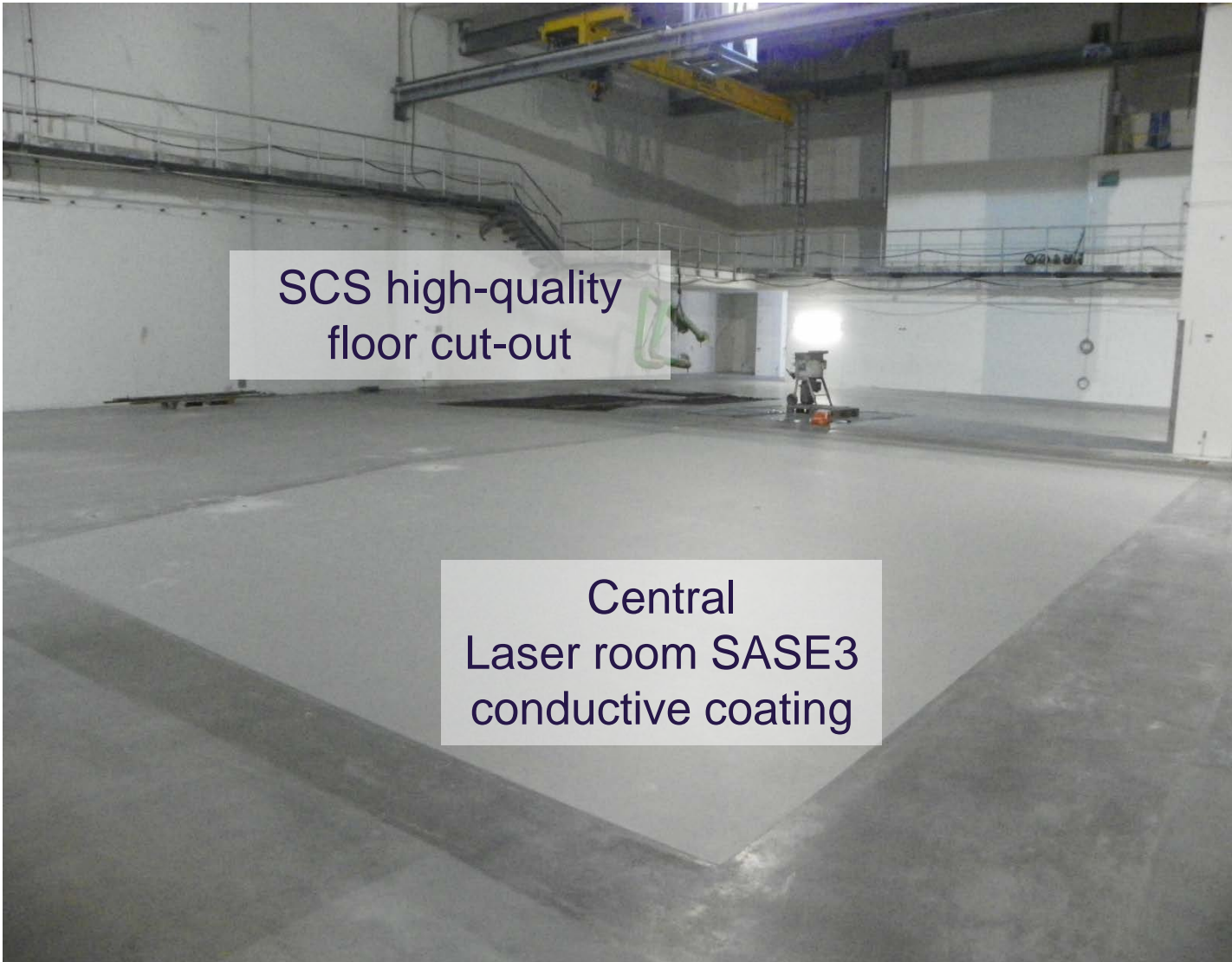
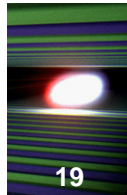
“Normal” floor

T. Haas,  
G. Wellenreuther

Technical  
Coordination

Photon Systems  
Project Office  
Group

# Floor coatings and preparations

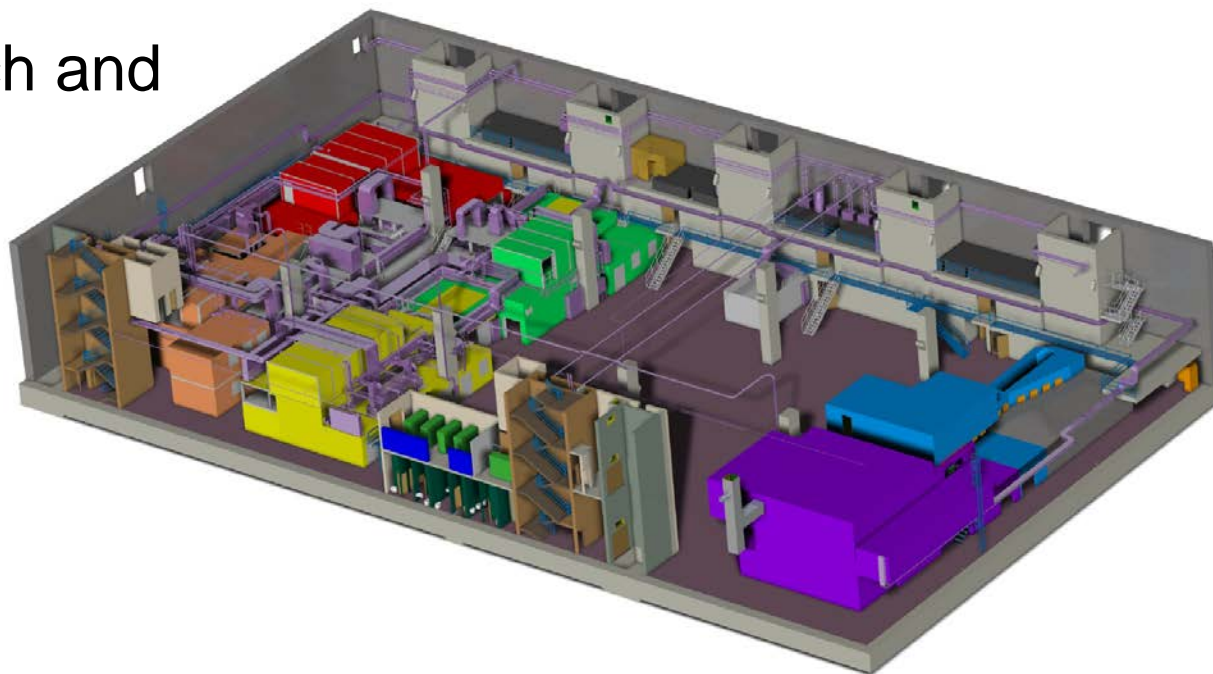


SCS high-quality  
floor cut-out

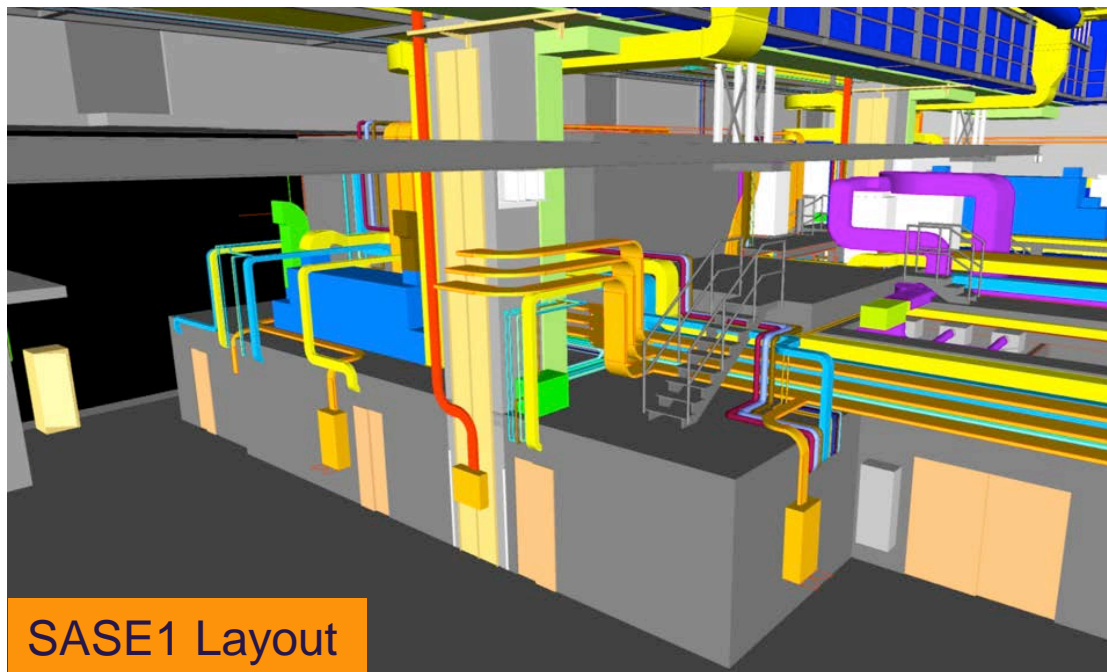
Central  
Laser room SASE3  
conductive coating

Next:  
Start construction  
of SASE1  
hutches  
(February)

- Cost and schedule driver.
- In May 2014 we organized a special review on the hutch infrastructure requirements, technical implementation and corresponding cost estimates, by a panel of external experts.
- The basic approach and estimates were supported by the panel.



- Experiment hutches and infrastructure to be completed by:
  - Priority on SASE 1 → Jan 2016
  - Next SASE 3 → May 2016
  - Then SASE 2 → August 2016



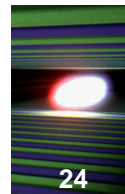
SASE1 Layout

## Challenges:

- European XFEL instruments are complex, and need to integrate contributions of many work packages (Optics, Diagnostics, Detectors, Lasers, Advanced Electronics, etc.)
  - Installation of different instruments shall overlap in time
  - Technical resources limited, in some cases provided by/shared with DESY
- Need careful and precise planning

- K. Piórecki of the the PSPO group developed a standardized Work Breakdown Structure and a template time schedule that are being iteratively filled by the PSPO, the respective instrument groups and involved technical groups.
- Regular updates and “walk-through” meetings are keeping the schedules in sync with relevant new aspects (e.g. schedule of external contracted companies)

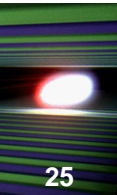
## Megapixel 2Dim detectors with 4.5 MHz response



Detector Parameters	Adaptive Gain Integrated Pixel Detector (AGIPD) <i>SPB, MID</i>	Large Pixel Detector (LPD) <i>FXE</i>	DEPFET Sensor with Signal Compression (DSSC) <i>SCS, SQS</i>
Energy range (keV)	3–13	5(1)–20(25)	0.5–6(25)
Dynamic range (photons/pixel/pulse)	$10^4$ @ 12 keV	$10^5$ @ 12 keV	6 000 @ 1 keV
Single Photon Sensitivity	yes	yes	yes
N. of intermediately stored images	~ 360	512	~ 800
Pixel size ( $\mu\text{m}^2$ )	200 X 200	500 X 500	236 X 236

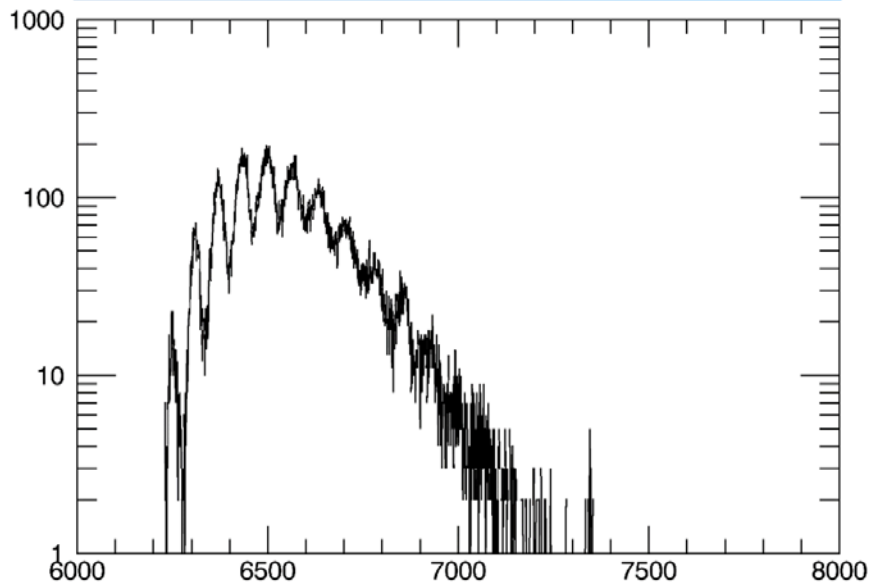


# Tests of reduced area prototypes

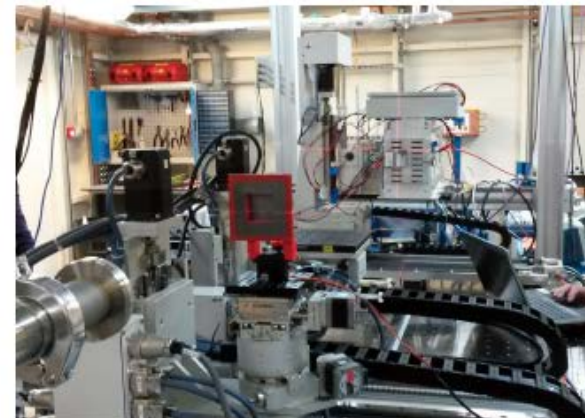


## AGIPD @ APS

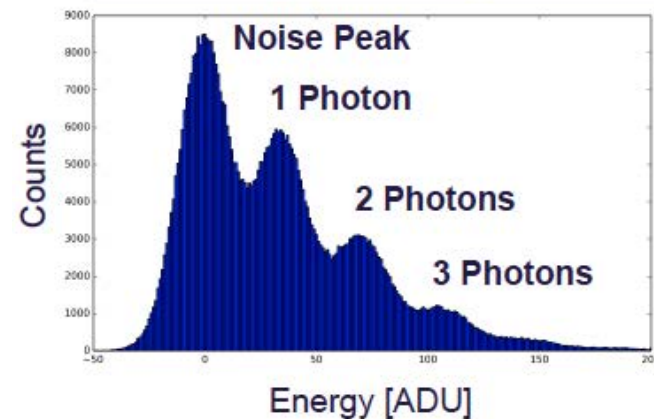
- Photon energy: **10 keV** (monochromatic)
- Beam focused by KB-mirrors on single pixel
- Scanning dynamic range by means of attenuators
- Recording of frames at **6.5 MHz**, putting result into histogram:  
→ Single photon resolution at 6.5 MHz



## LPD @ DIAMOND

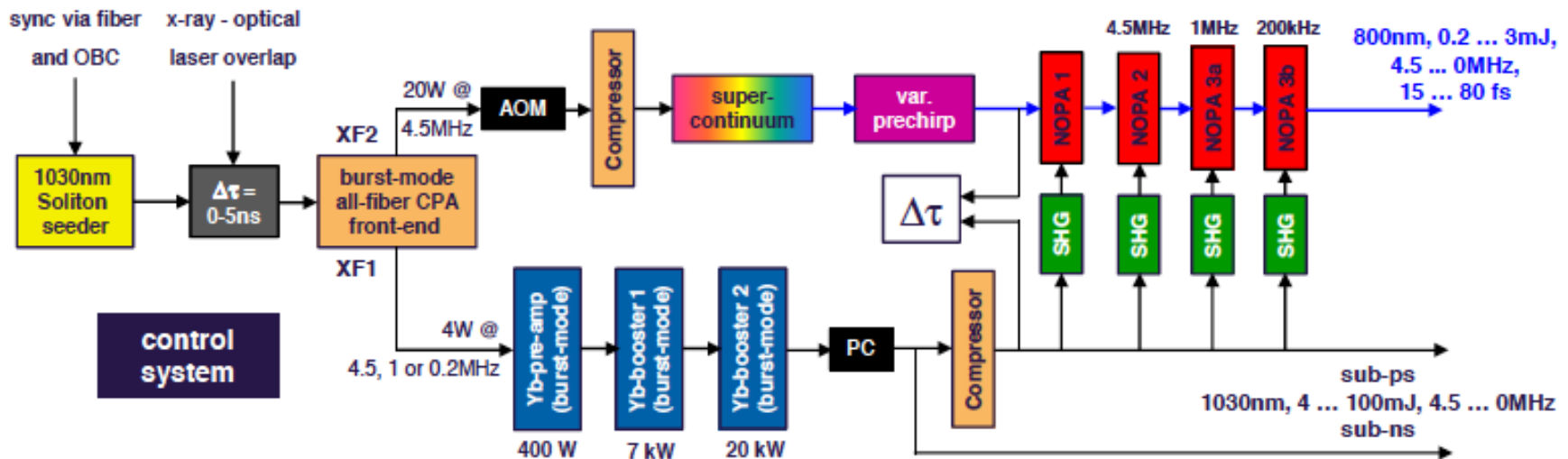


## Photon Spectrum @ 18 keV

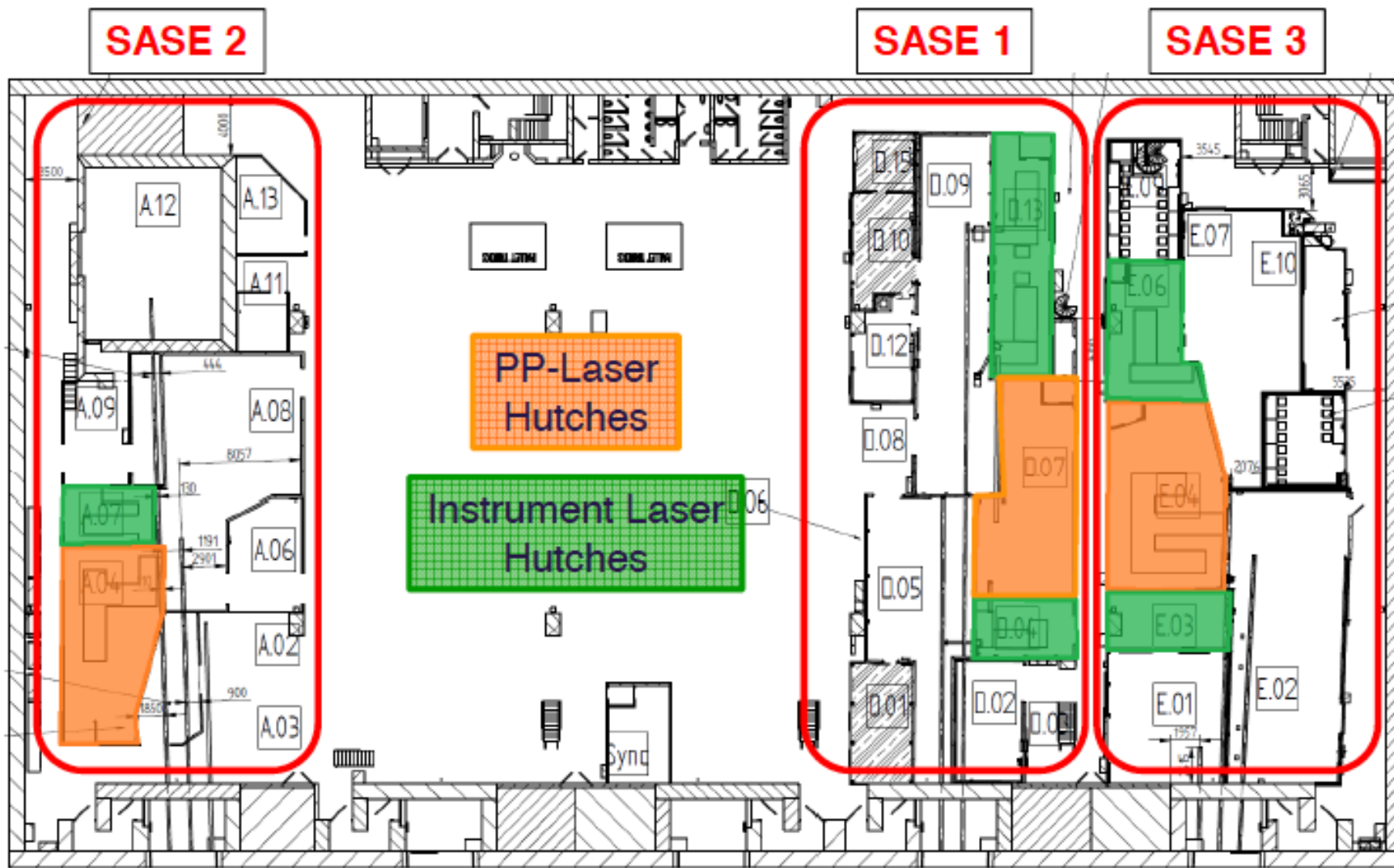
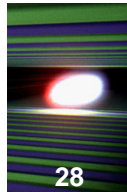


- As a result of mission changes and restructuring of the leading consortium institution, the project entered in a problematic phase last year.
- It was decided to simplify the sensors (adopt the so-called mini-SDD, or “day-0” sensors) in order to have a working detector, albeit with reduced performance, in mid 2016. Solutions for production of the original high performance sensors with different sets of partners are being pursued.

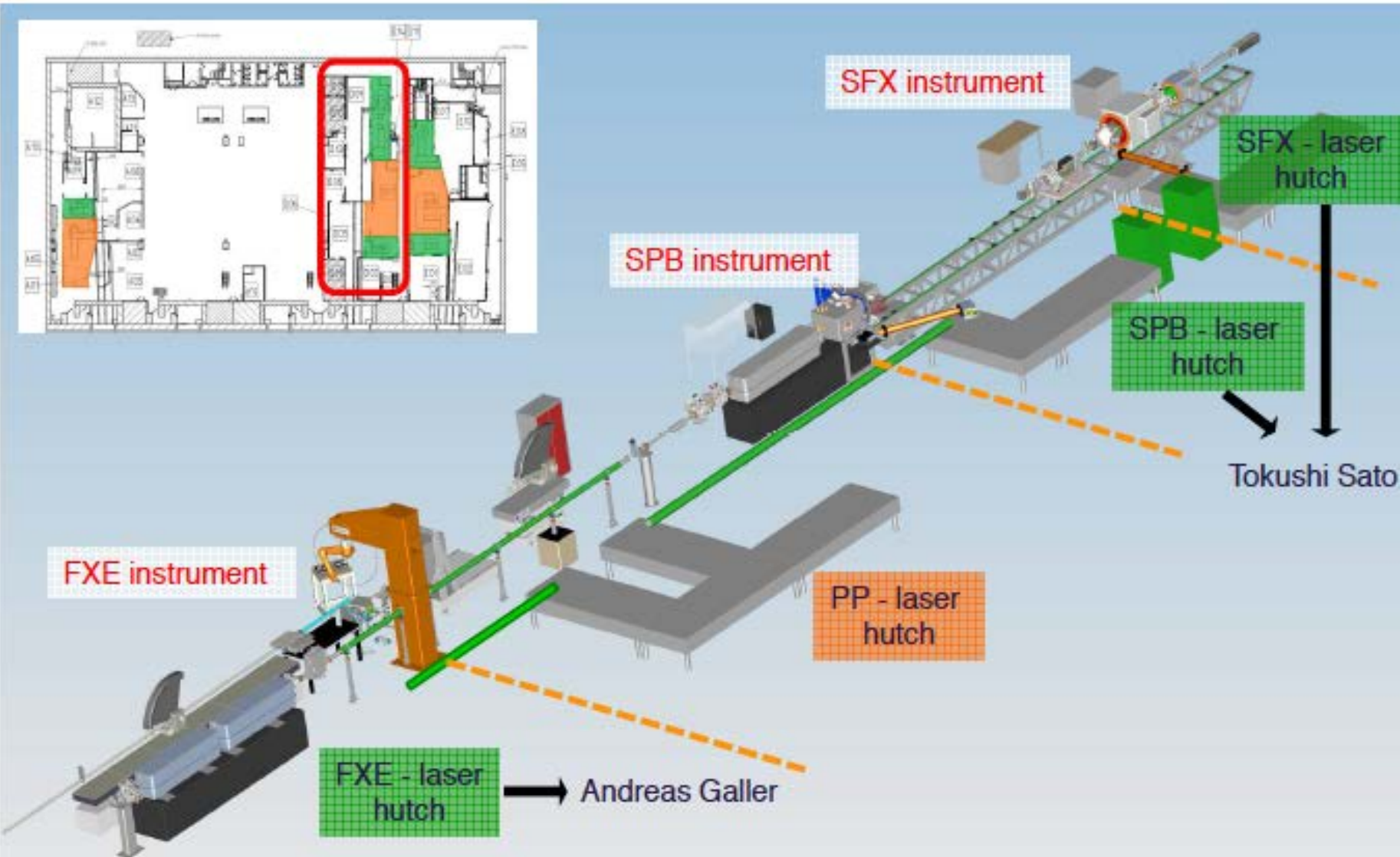
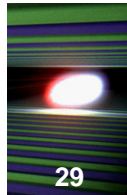
- WP78, M. Lederer
- Goals:
  - Synchronized few-cycle laser pulses with energy up to the few mJ-level
  - 10 Hz bursts (600 $\mu$ s) with intra-burst rep. rate up to 4.5MHz



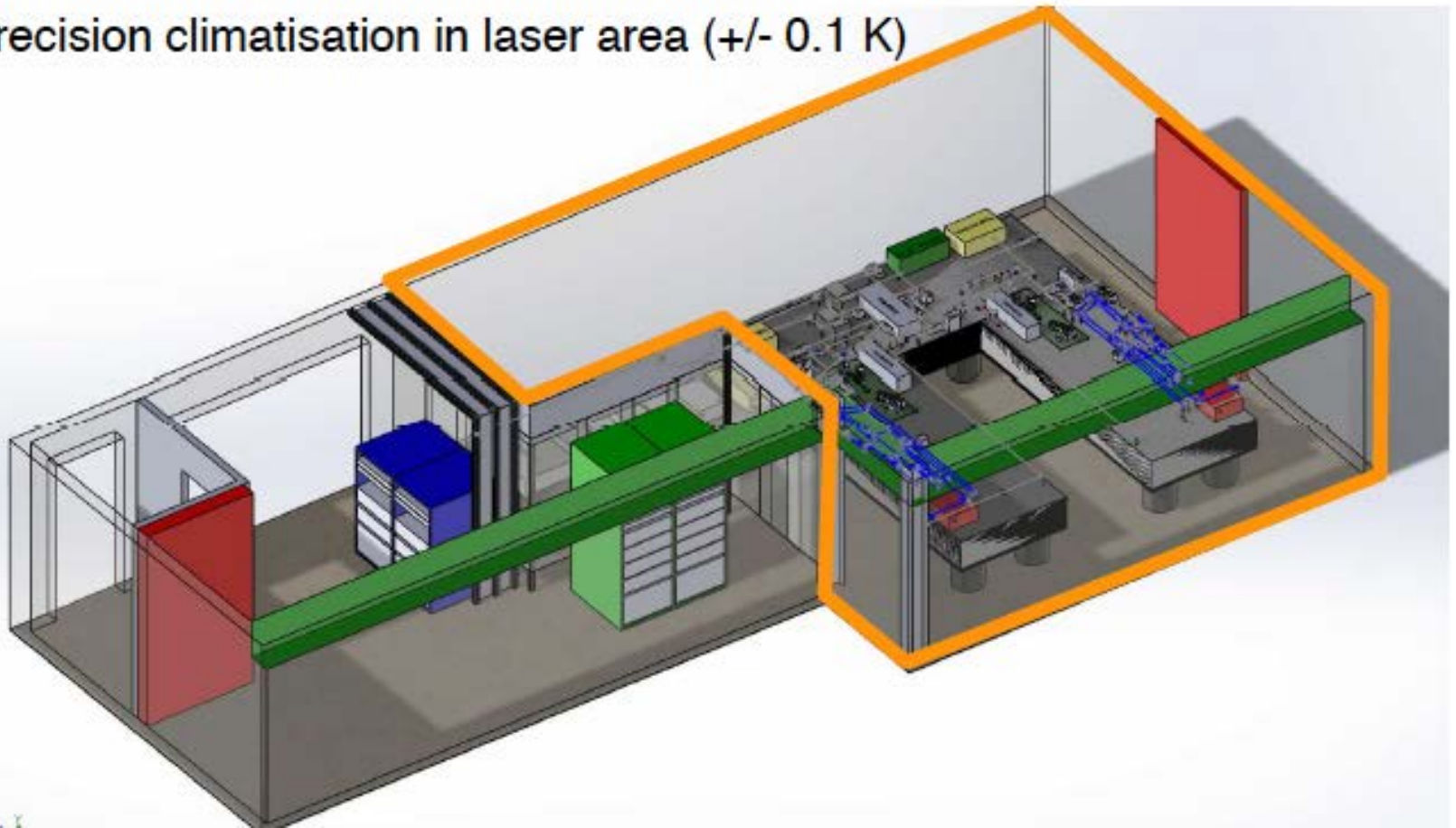
# Laser location in the Experiment Hall



# Lasers for SASE1 instruments

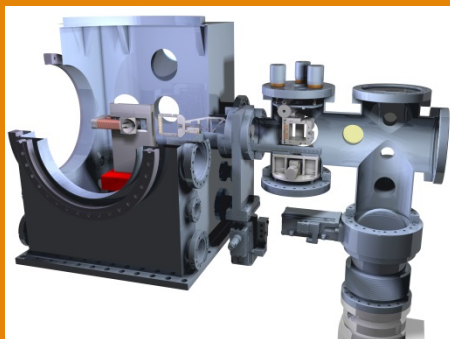


- Different climate zones:
  - Air-condition in preparation/rack area ( $\pm 0.5$  K)
  - Precision climatisation in laser area ( $\pm 0.1$  K)



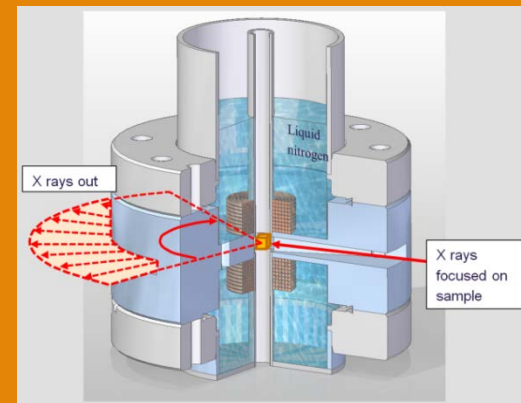
## Fixed target scanner

- Prototype for SCS
- Includes sample exchange
- Ready to be built in 2015



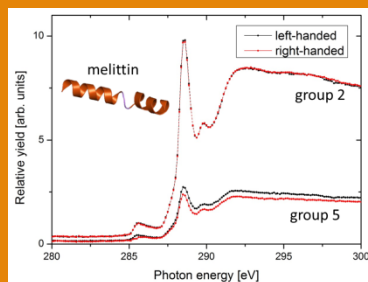
## Compact pulsed magnets

- Conceptual design
- ~30 Tesla
- For MID, SCS & HED
- Collaborate with HIBEF



## Liquids and aerosols

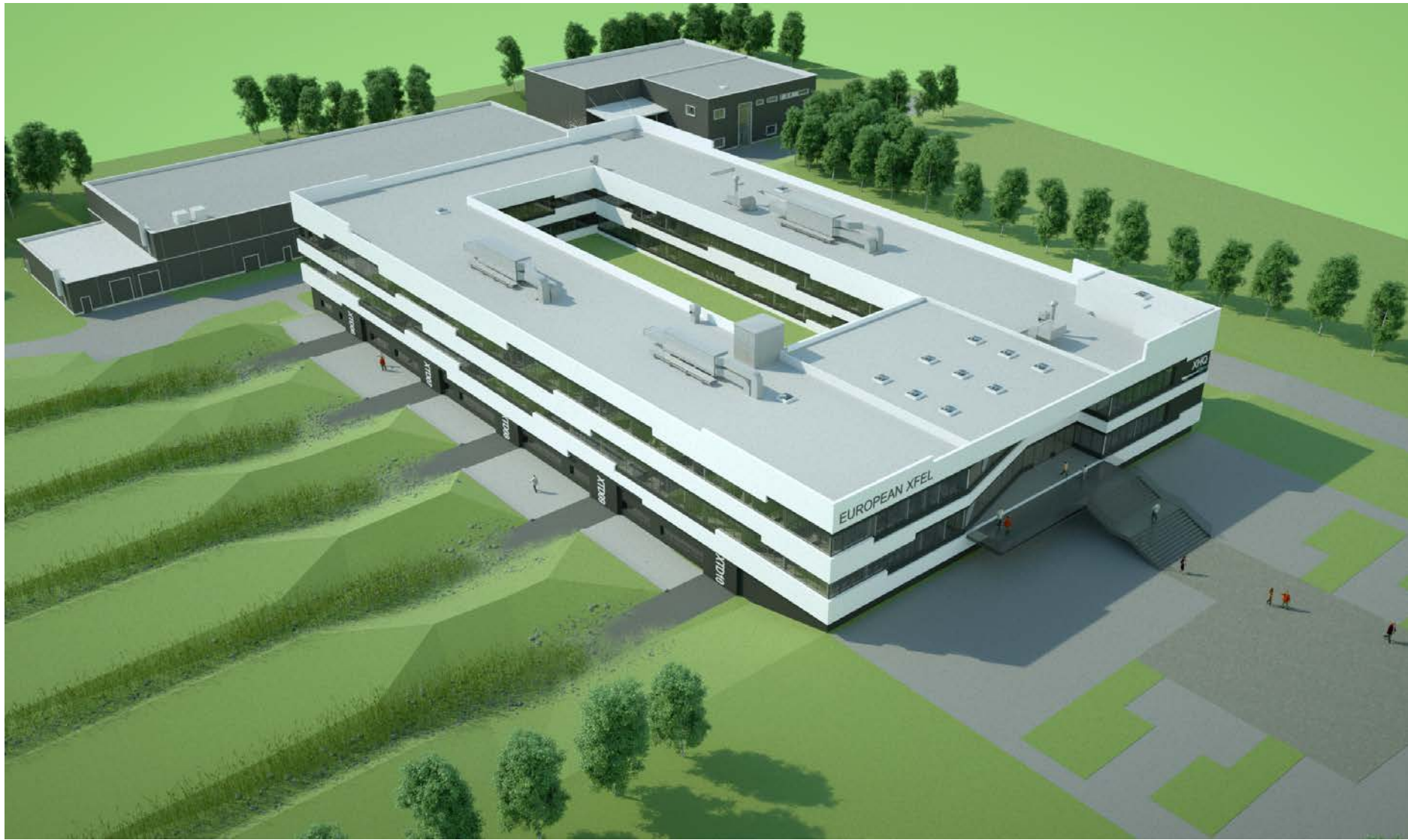
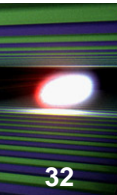
- Experiments with electrospray source at BESSY II
- Collaboration with Heinrich-Pette-Inst.
- Coordination with SFX user consortium



## User laboratories & support

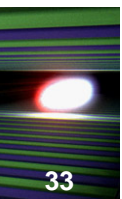
- ~520 m<sup>2</sup> biology laboratory facility in cooperation with the XBI user consortium
- ~70 m<sup>2</sup> sample preparation laboratories
- ~50 m<sup>2</sup> chemistry laboratories
- Preparation of user support concept

# XHQ building, construction started May 2014





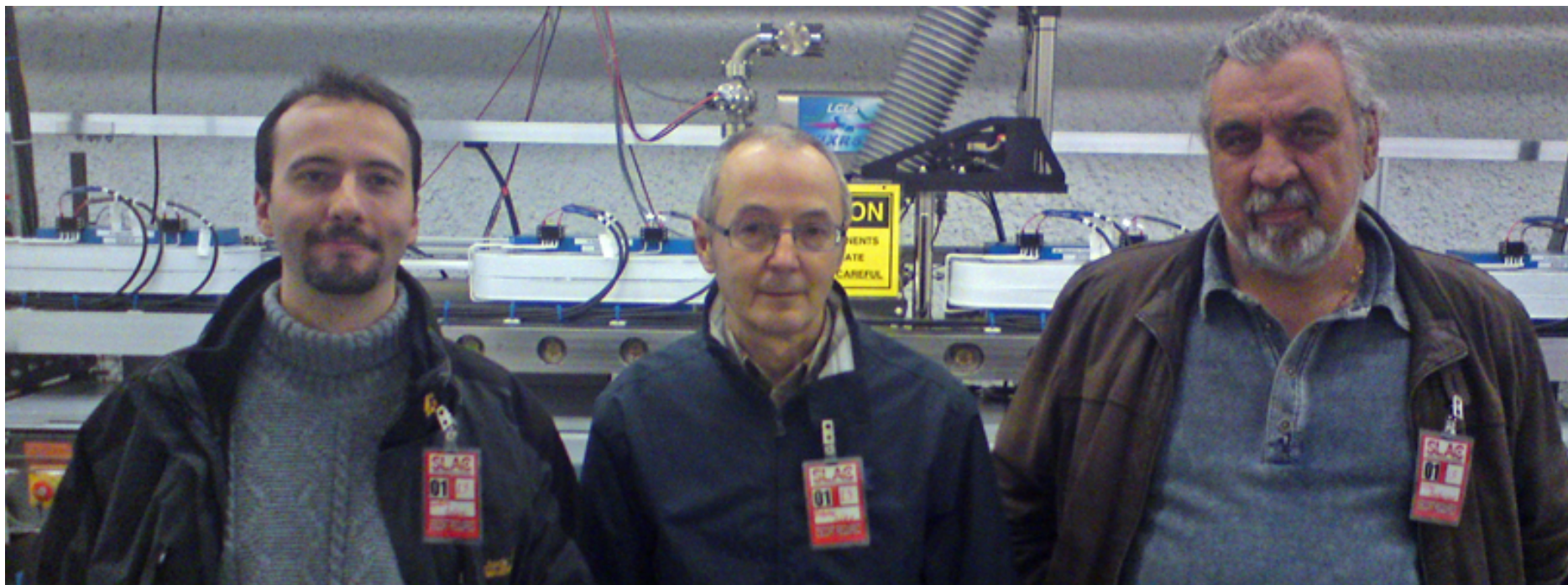
# XHQ building, Jan. 2015



Richtfest, 18.02.2015!



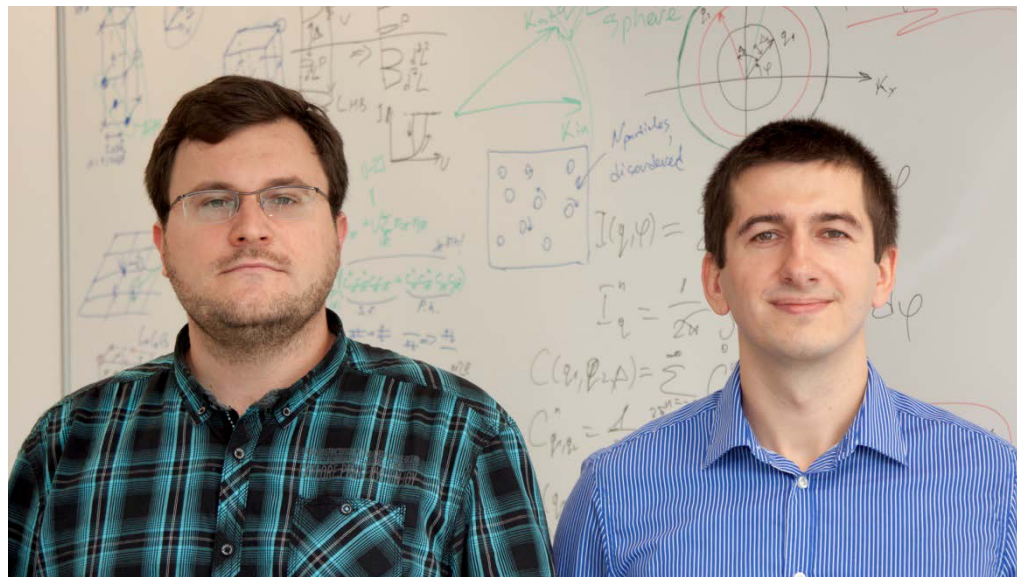
- In the area of FEL beam generation and properties, well-established activities by the group of G. Geloni (XFEL.EU) and E. Saldin, V. Kocharian, E. Schneidmiller, and M. Yurkov (DESY), continue.



- To provide theoretical stimulation and support for FEL experiments, a collaboration between XFEL.EU and the University of Hamburg (Professor A.I. Lichtenstein) was started, with two junior scientist positions from European XFEL



A.I. Lichtenstein

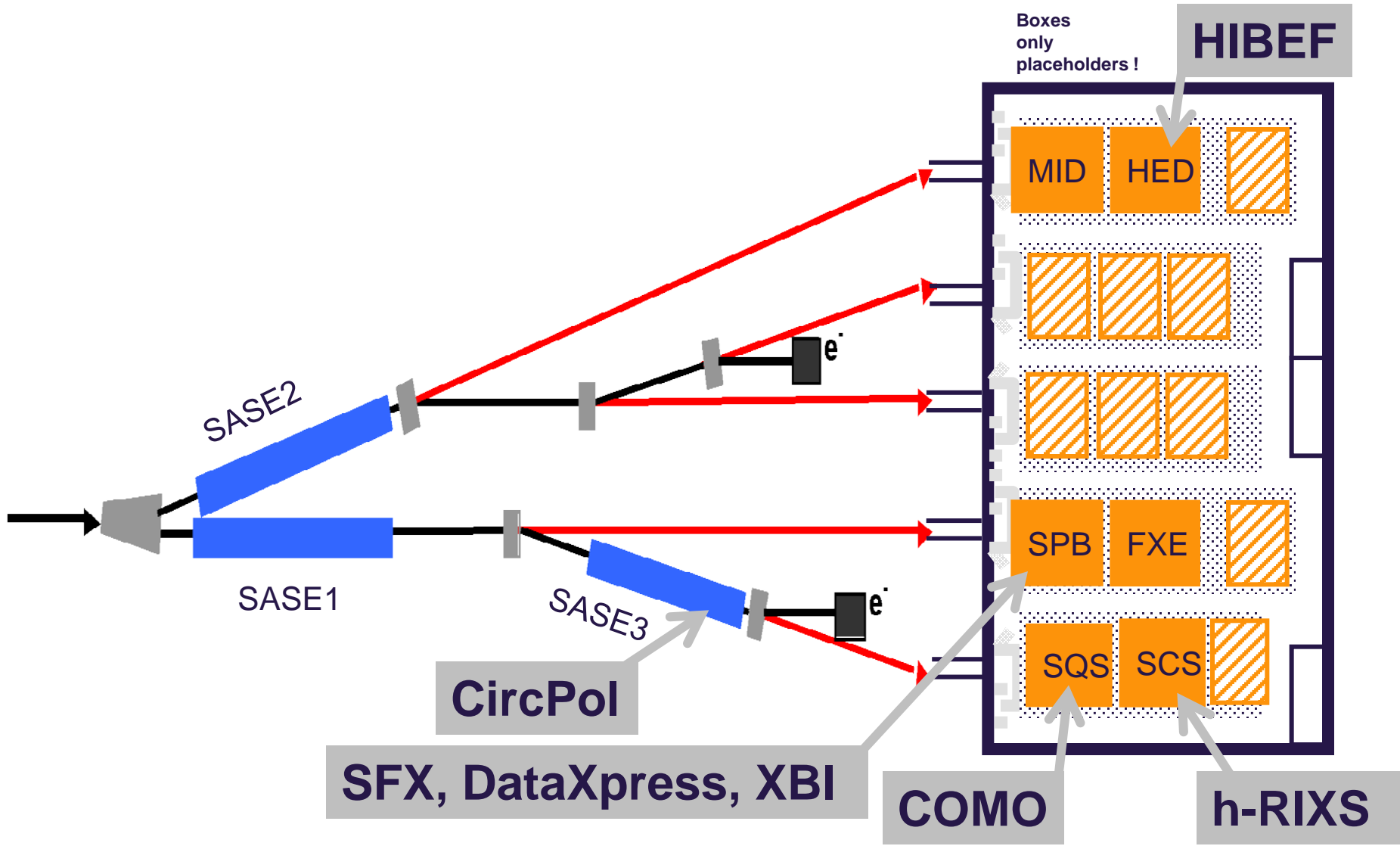
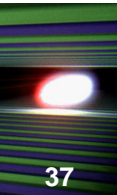


E. Gorelov

R. Kurta

# User consortia: presently received proposals

- 1. Bio-labs in XHQ, ancillary facilities **UseXBI**
- 2. Expansion of computational capabilities **DataXpress**
- 3. A station for nanocrystallography on a hard X-ray branch **SFX**
- 4. High-energy lasers and pulsed high field magnet for the High Energy Density Instrument **HIBEF beamline**
- 5. An additional versatile experimental chamber for oriented molecular species **COMO**
- 6. A RIXS station for the soft X-ray branch **h-RIXS**
- 7. A helical afterburner, to produce variable polarization soft X-rays **CircPol**



# Coming soon: Users at the European XFEL!



© Getty

- To be built up in the coming months, to handle the whole process: proposals, evaluation, communication, travel, follow up, statistics
- To be the reference point of all users



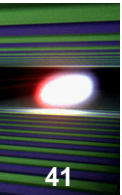
Silvia Bertini

# Tentative timetable...

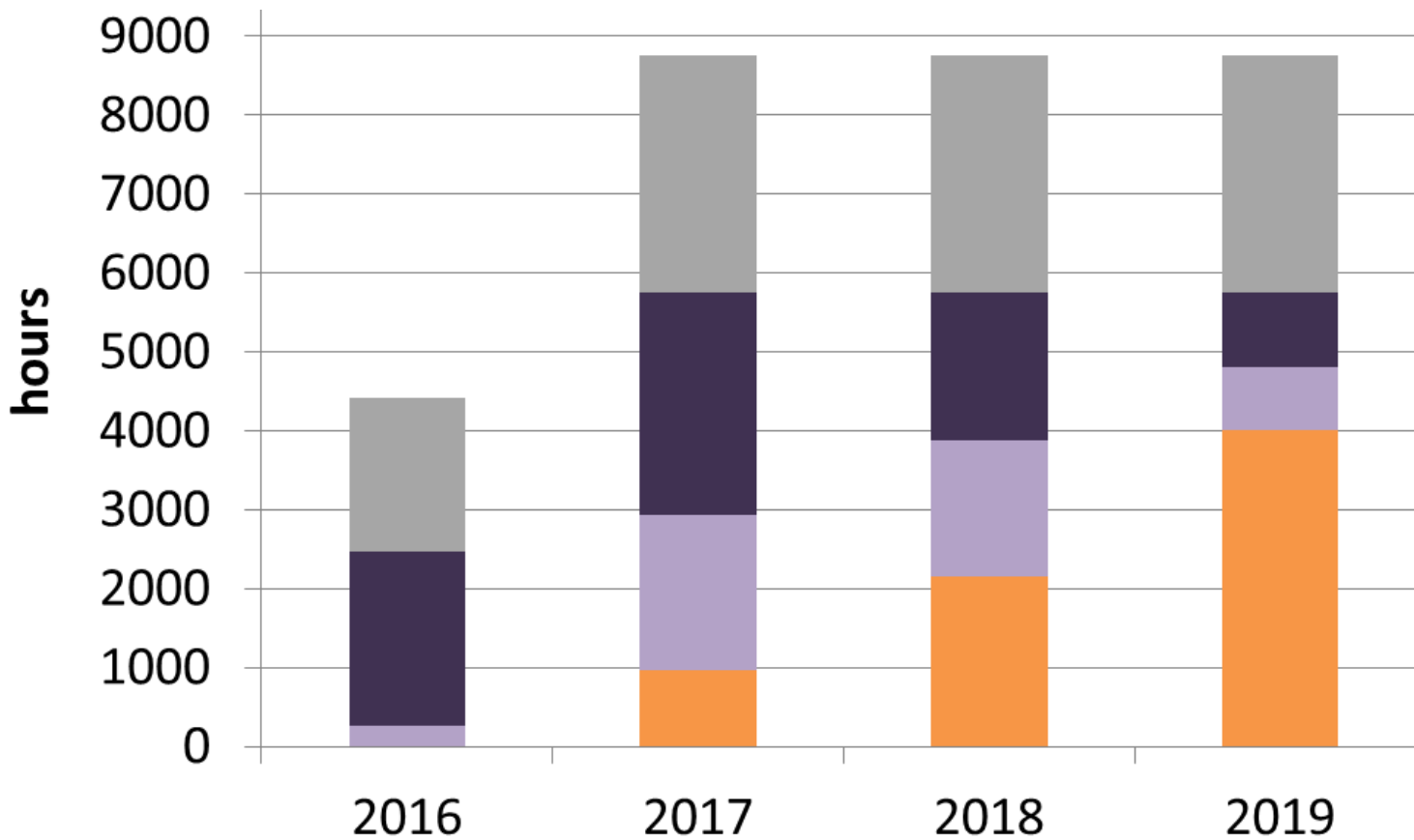
- 2016** Initial commissioning of linac, to bring electron beam in first undulator (SASE1). **Enable first lasing.**
- 2017** Bring X-ray FEL beam to XHEXP.  
Continue commissioning of accelerator.  
Initial commissioning of X-ray beam transports and instruments.  
**Start “early user experiment” programme (peer-reviewed).**
- 2018** Reach full performance of accelerator.  
Development of X-ray beam transports and instruments towards full performance.  
**Continue “early user experiment” programme (peer-reviewed).**  
**During 2nd half 2018 start full scope user programme (peer-reviewed).**
- 2019** Regular operation (4000 hrs for user programme).



# This means...(see presentation W. Decking)

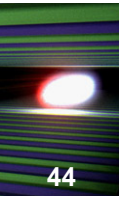


Scheduled down & maint.
  Acc development
  X-ray development
  User program



- Performance (both accelerator and X-ray) and operational flexibility will improve during commissioning and further development phases
  - 2017
    - limited operation parameters of accelerator (electron energy, bunch charge, compression, fill patterns)
    - serve one SASE FEL at the time
    - initial operation of X-ray transports (including photon diagnostics)
    - initial operation of instruments with large suite of apparatuses in need of commissioning with X-ray beam

- Early User Experiments need to expect
  - Limited X-ray performance and operational flexibility.
  - The latter will lead to restrictions in the choice of beam and X-ray parameters.



## **Peer-review of scientific and instrumentation proposals**

- Will be installed from the beginning
- Probably 1 (or 2) calls for Early User Experiment phase in 2017/2018
- Regular calls for user operation starting in 2nd half of 2018

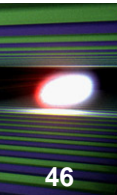
## **Science instruments start early user experiments in sequence**

- SASE 1 instruments FXE and SPB/SFX first in May 2017
- SASE 3 instruments SQS and SCS next in June 2017
- SASE 2 instruments MID and HED last in August 2017

## **Details to be presented at Users' Meeting in January 2016**

- I wish to thank the whole staff of the European XFEL for the work presented here...

...and thank you for your attention!



## In-kind Contributions

### Accelerator Consortium

Coordinator:  
**DESY**  
*Institutes from D,  
F, I, CH, PL, ES,  
RU, DK, SE...*

### Other In-kind Contributors

## European XFEL GmbH

### Council

Chair: M. Meedom Nielsen

### Management Board

Managing Directors

*M. Altarelli, Chair*

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## Some news on Dec. 17, 2014

- “Minister for Universities and Science Greg Clark MP today announced the United Kingdom will invest up to £30 million to become a full member of the European XFEL facility, now under construction near Hamburg, Germany.”
- Mr Clark said: “This facility will generate intensely bright and short duration X-ray flashes when operational in 2018. It will open areas of research for British scientists at the atomic, molecular and nano-scale level that are currently inaccessible.”
- “Today’s announcement shows our determination to ensure UK science remains at the very forefront of global research....Access to the new science areas made possible by the new technology has been identified as a priority for UK science.”