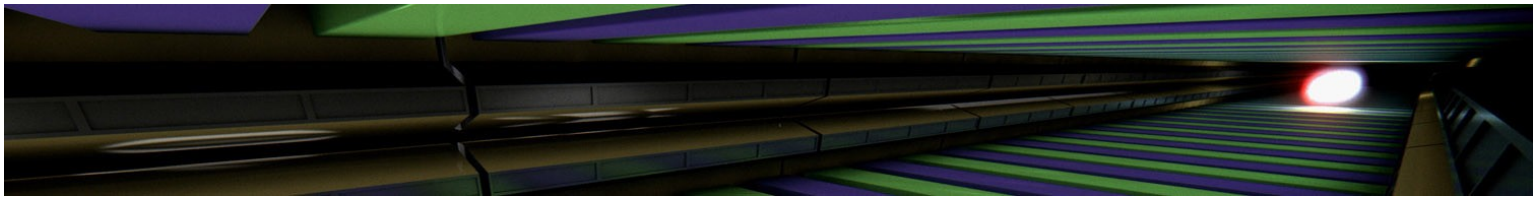
European XFEL



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

Massimo Altarelli

European X-ray Free-Electron Laser Facility

22607 Hamburg, Germany

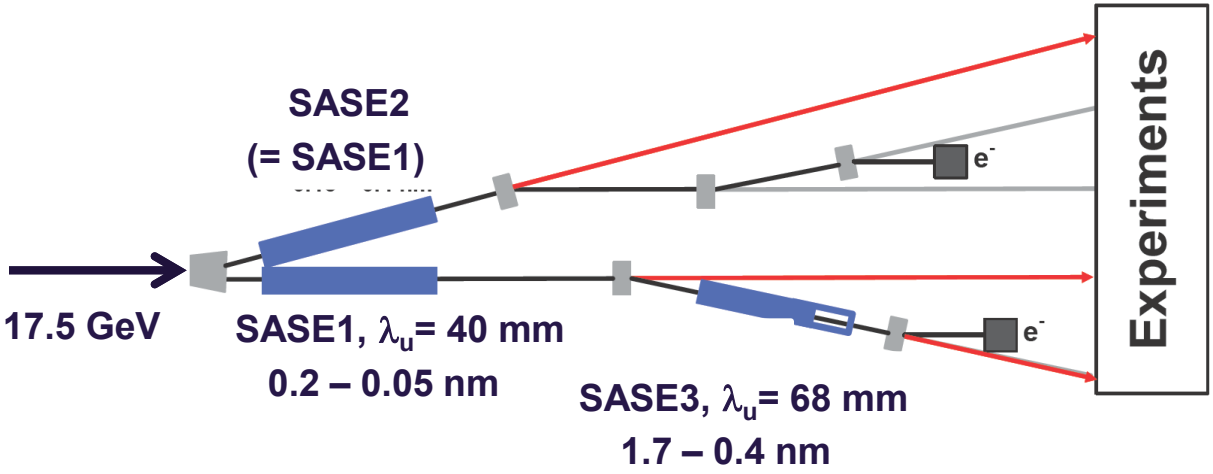
massimo.altarelli@xfel.eu

The European XFEL

Some specifications

- Photon energy 0.3-24 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 beamlines and 6 instruments
- Several extensions possible:
  - More undulators
  - More instruments
  - …….
  - Self-Seeding
  - CW operation

First beam late 2015



European XFEL

Schedule: no room for errors for XFEL.EU!

- LCLS: April 2009,
  1.5 Å coherent x-rays!

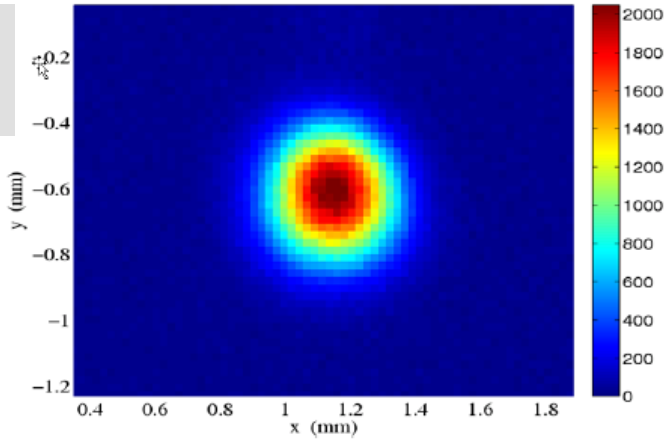
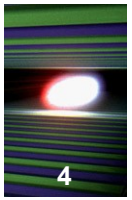


Figure 10: FEL x-rays at 1.5 Å on a YAG screen 50 m after the last inserted undulator (see Table 1 for measured parameters).

- SACLA, Spring-8:
  April 2011, first SASE beam

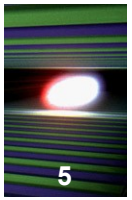
Fundamental Milestones



- Start of Injector Commissioning:
  1 June 2014

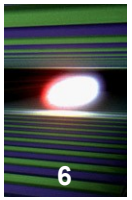
- First e^- beam in Linac:
  15 October 2015

Important Council Decisions in 2011



- Strong commitment of shareholders to support the project financially, following German-Russian initiative
- Final decision for 17.5 GeV Linac energy

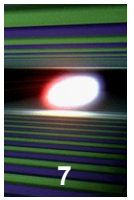
The European XFEL



- About 1 100 M€ Project (Investment, Personnel, Commissioning)

- 240 M€ Underground Construction
- 30 M€ Above ground…
- 550 M€ Accelerator and Infrastructure
- 180 M€ Undulators, Photon Beamlines, Instruments
- 50 M€ Commissioning
- 50 M€ Administration, overheads,…..

Organization of the European XFEL Project



In-kind Contributions

Accelerator Consortium

Coordinator:

DESY

Institutes from D, F, I, CH, PL, ES, RU, CN, SE…

Other In-kind Contributors

European XFEL GmbH

Council

Chair R. Feidenhans'l

Management Board

Managing Directors

M. Altarelli, Chair

C. Burger, Admin. Director

Scientific Directors

S. Molodtsov

A. Schwarz

T. Tschentscher

Advisory Committees

SAC

MAC

AFC

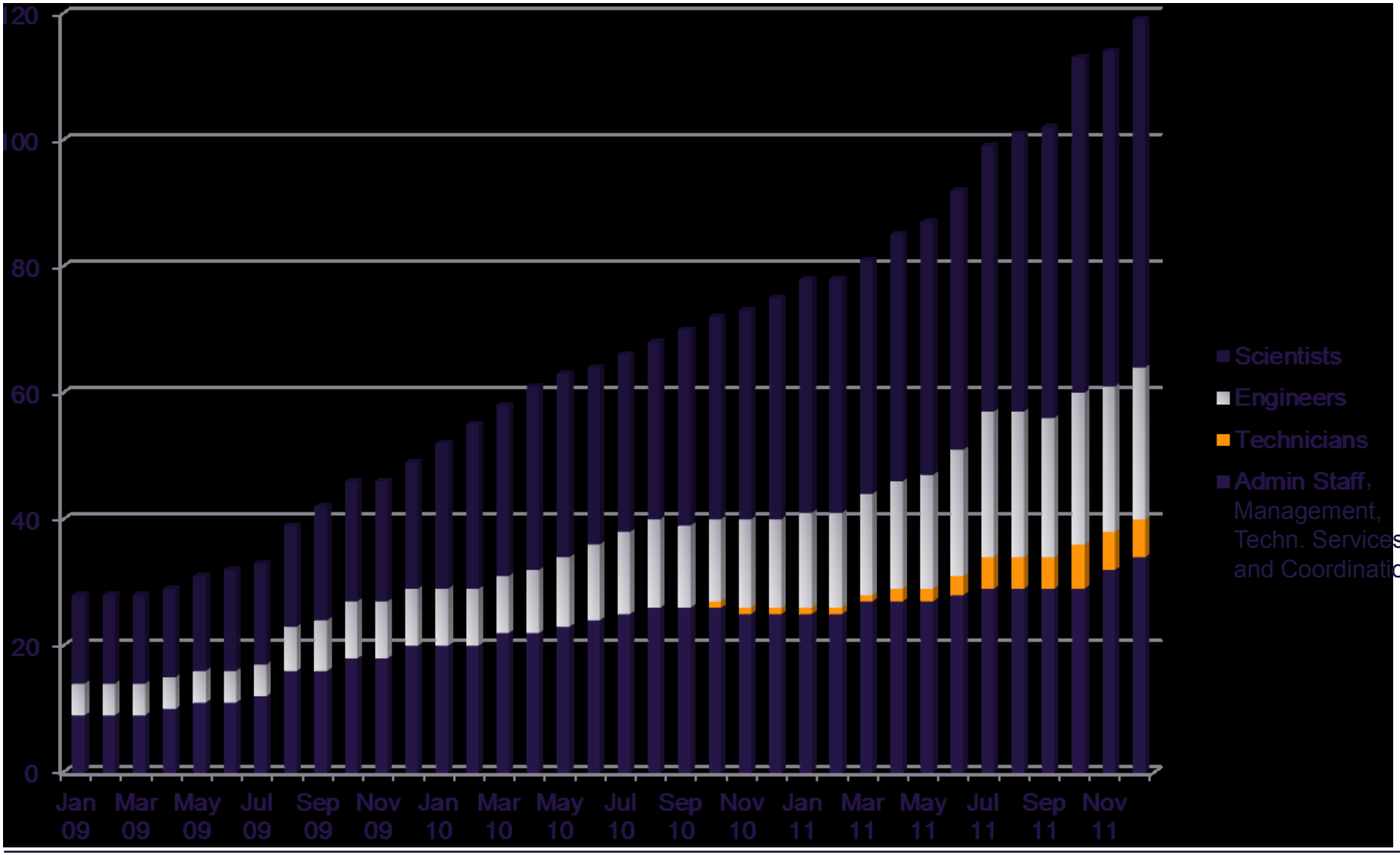
IKRC +

Det. AC

Lasers AC

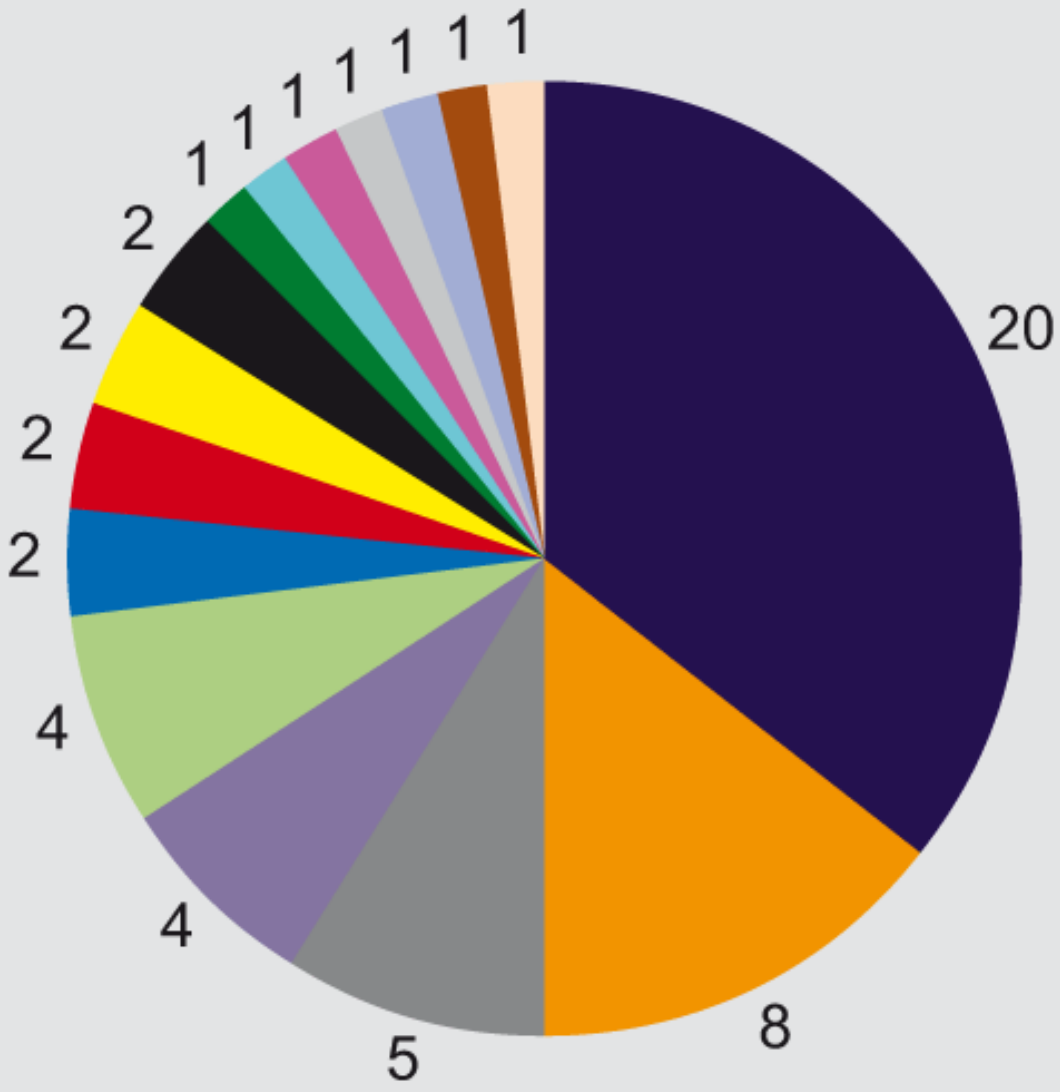
European XFEL

Staff recruited, November 2011



European XFEL

Nationality distribution of the scientific staff

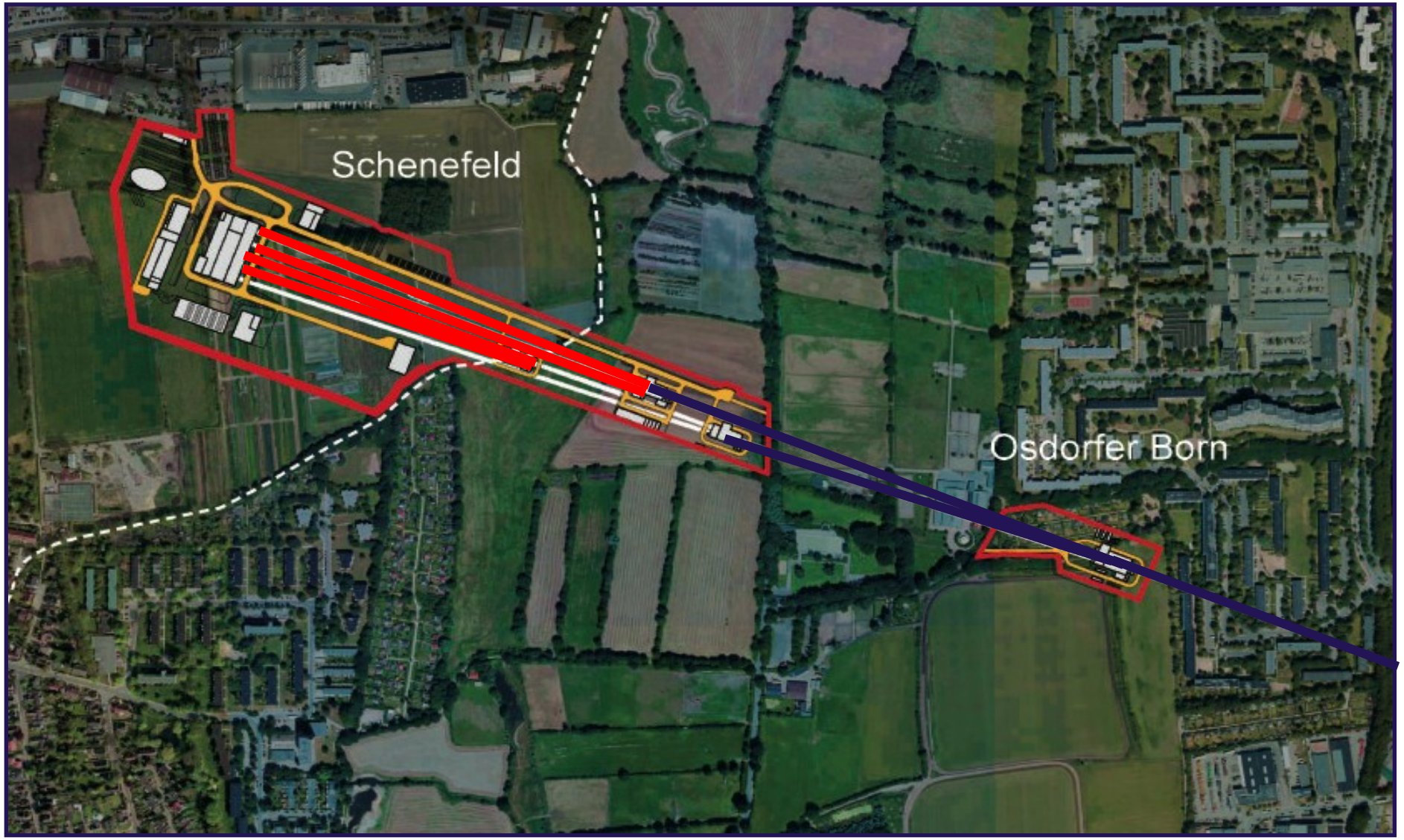


Germany	20
Russian Federation	8
Italy	5
China	4
Poland	4
France	2
Iran	2
Spain	2
United States	2
Algeria	1
Australia	1
Bolivia	1
Denmark	1
Turkey	1
Ukraine	1
United Kingdom	1
Total	**56**

European XFEL

Status 20 January, 2012

- Approx. 84% of tunnels finished
  - 100% of 5.2m diameter
  - ca. 66% of 4.5m diameter
  - 4850m of 5777m in total

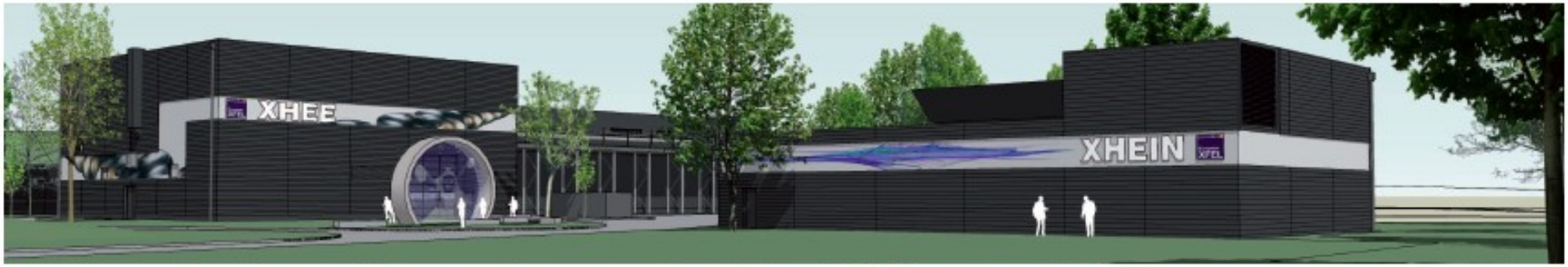

Schenefeld
Osdorfer Born

European XFEL

Injector Building and Modulator Hall

European XFEL

DESY-Bahrenfeld: Architect's view



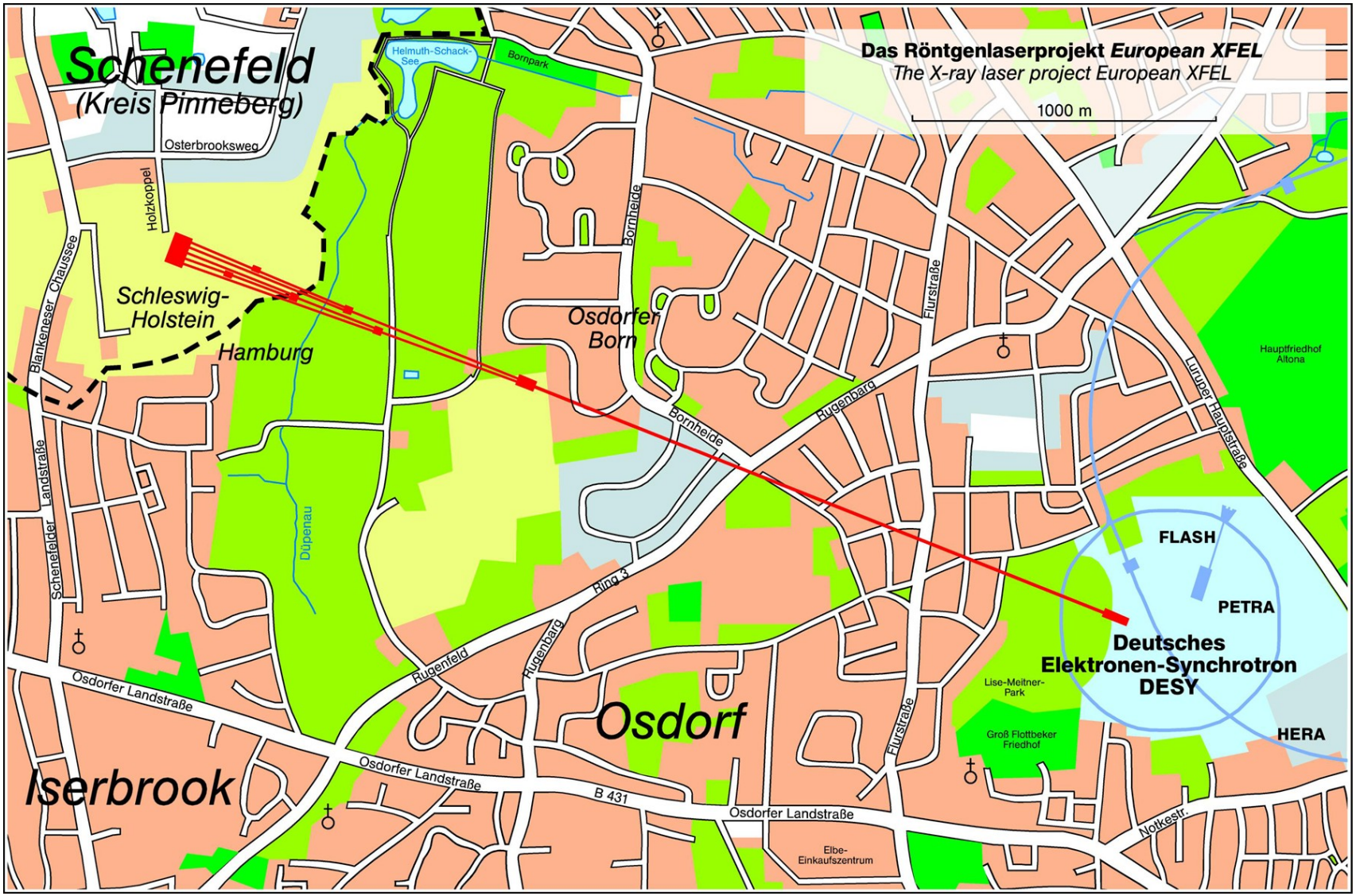
European XFEL

Injector Building

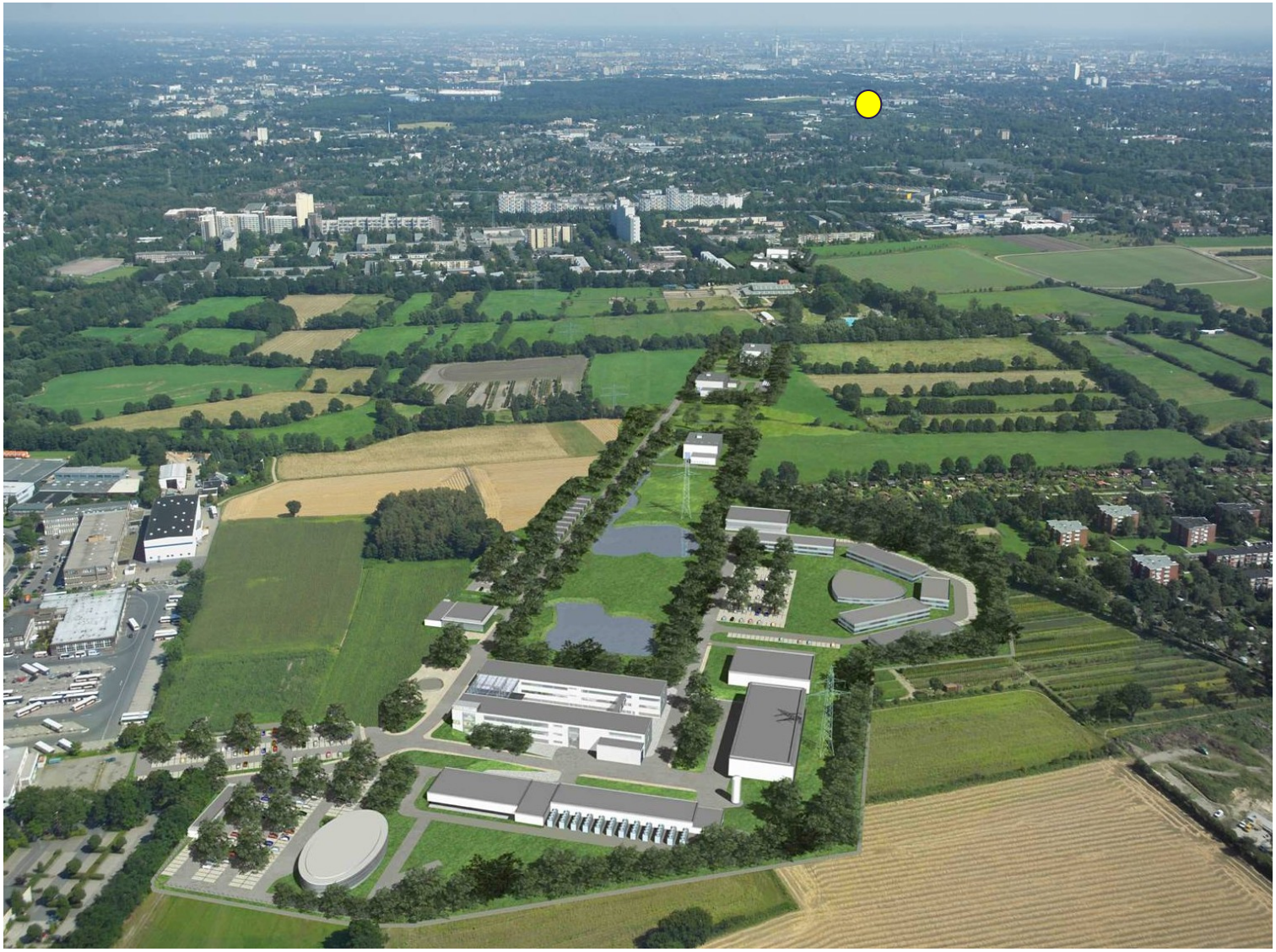
Linac Tunnel: preparing the floor

European XFEL

Linac Tunnel: the completed floor


Das Röntgenlaserprojekt European XFEL
The X-ray laser project European XFEL
1000 m
Schenefeld
(Kreis Pinneberg)
Helmuth-Schack-See
Bornpark
Osterbrooksweg
Holzkoppel
Blankeneser Chaussee
Schleswig-Holstein
Hamburg
Osdorfer Born
Bornheide
Flurstraße
Rugenberg
Lurupper Hauptstraße
Hauptfriedhof Altona
Landstraße
Schenefelder
Düpenau
Ring 3
FLASH
PETRA
Deutsches Elektronen-Synchrotron DESY
HERA
Rugenfeld
Osdorfer Landstraße
Osdorf
Lise-Meitner-Park
Groß Flottbeker Friedhof
Iserbrook
B 431
Elbe-Einkaufszentrum
Notkestr.

Schenefeld Campus 2015



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Schenefeld Campus, September 2011

European XFEL

Schenefeld Campus, September 2011

European XFEL

Experimental Hall, November 2010

European XFEL

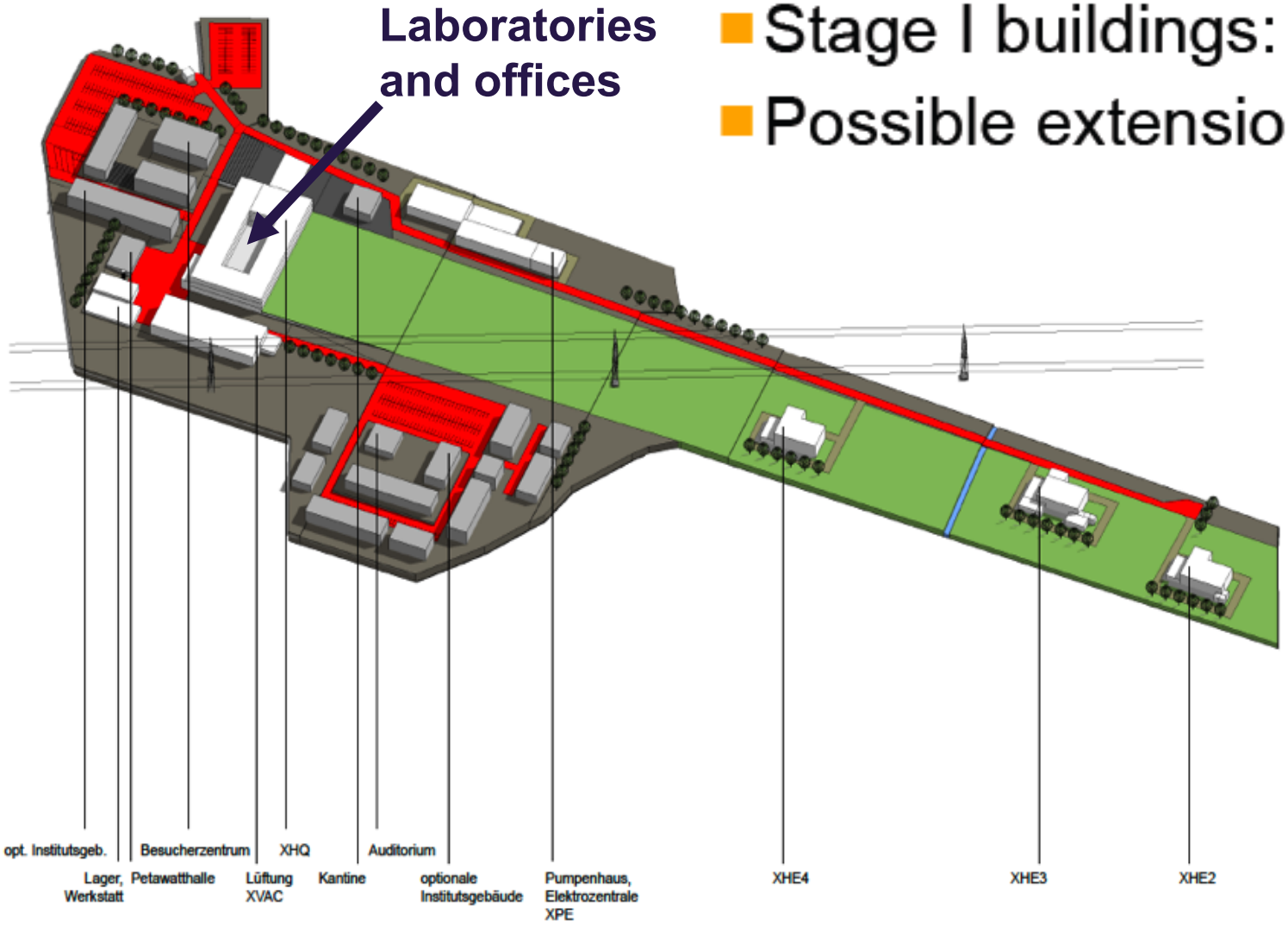
Experimental Hall, September 2011

European XFEL

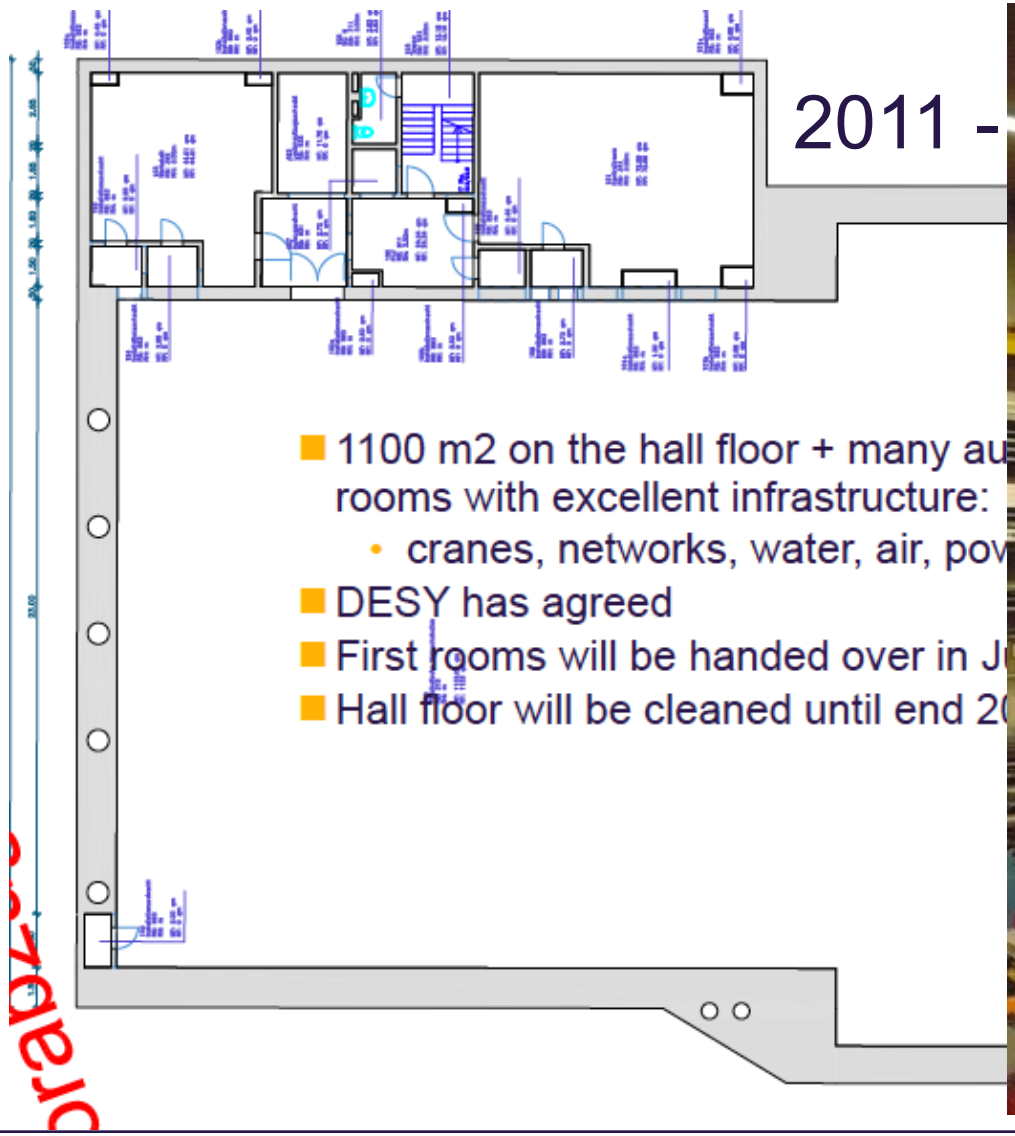
XTD1 (SASE1) Tunnel, 28. September 2011

European XFEL

Planning the Schenefeld Campus



HERA-S will be used as temporary lab area

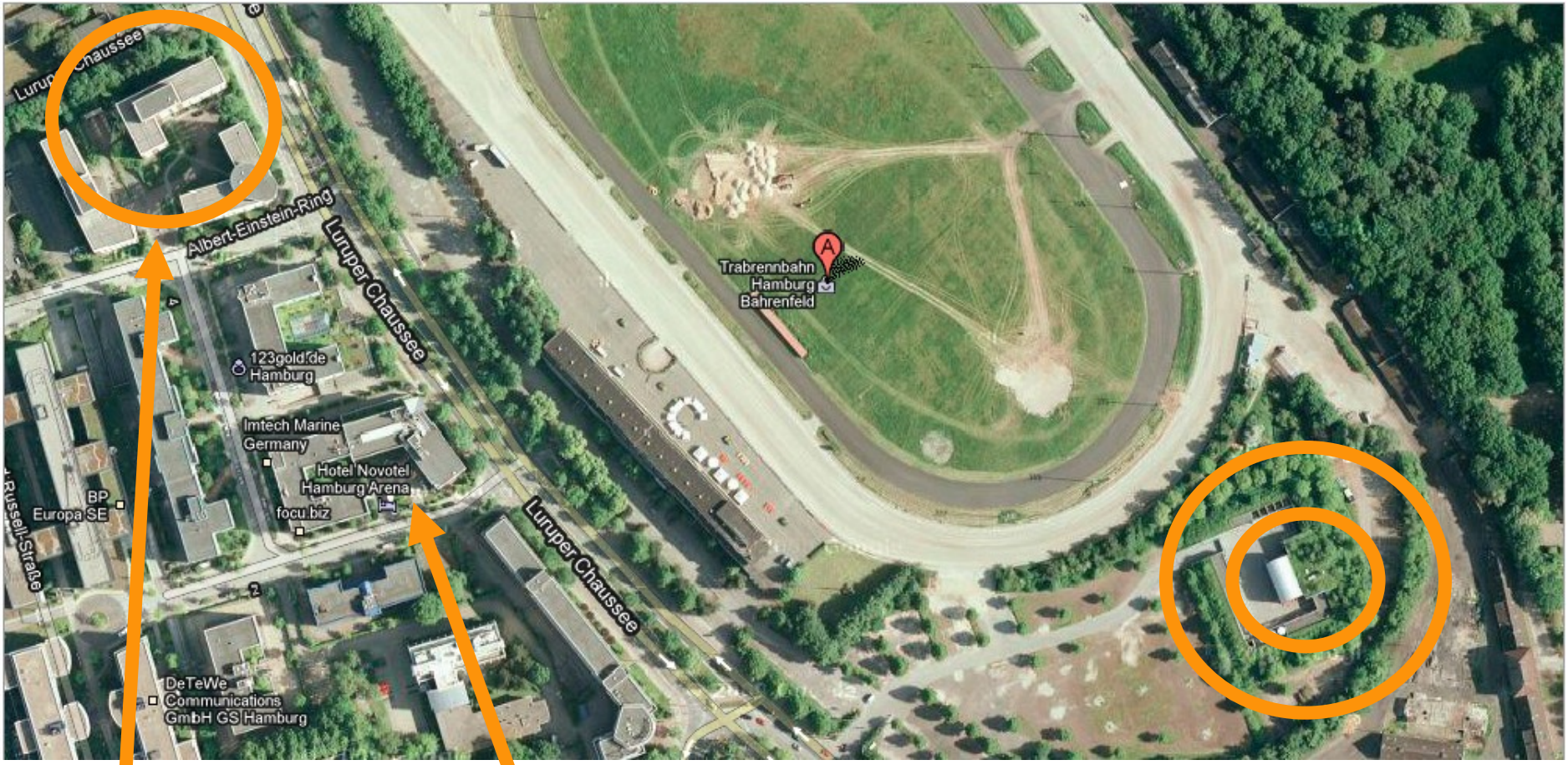


2011 -

- 1100 m2 on the hall floor + many au
  rooms with excellent infrastructure:
  - cranes, networks, water, air, pov
- DESY has agreed
- First rooms will be handed over in J
- Hall floor will be cleaned until end 2

European XFEL

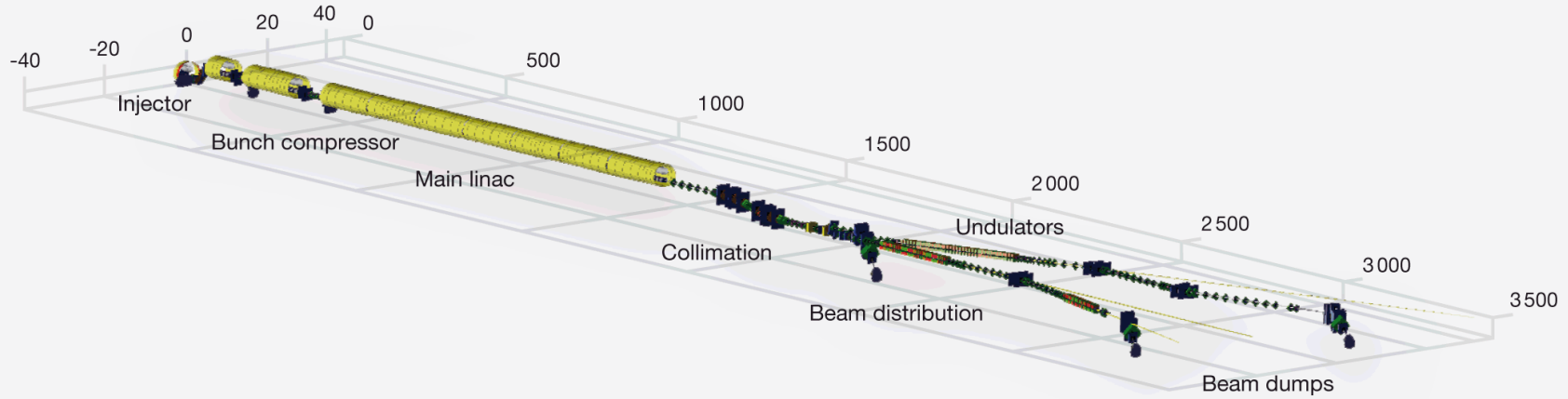
Location of HERA South Hall



European XFEL

Building for Laser Lab (ready spring 2012)

Accelerator Consortium (Courtesy H. Weise)



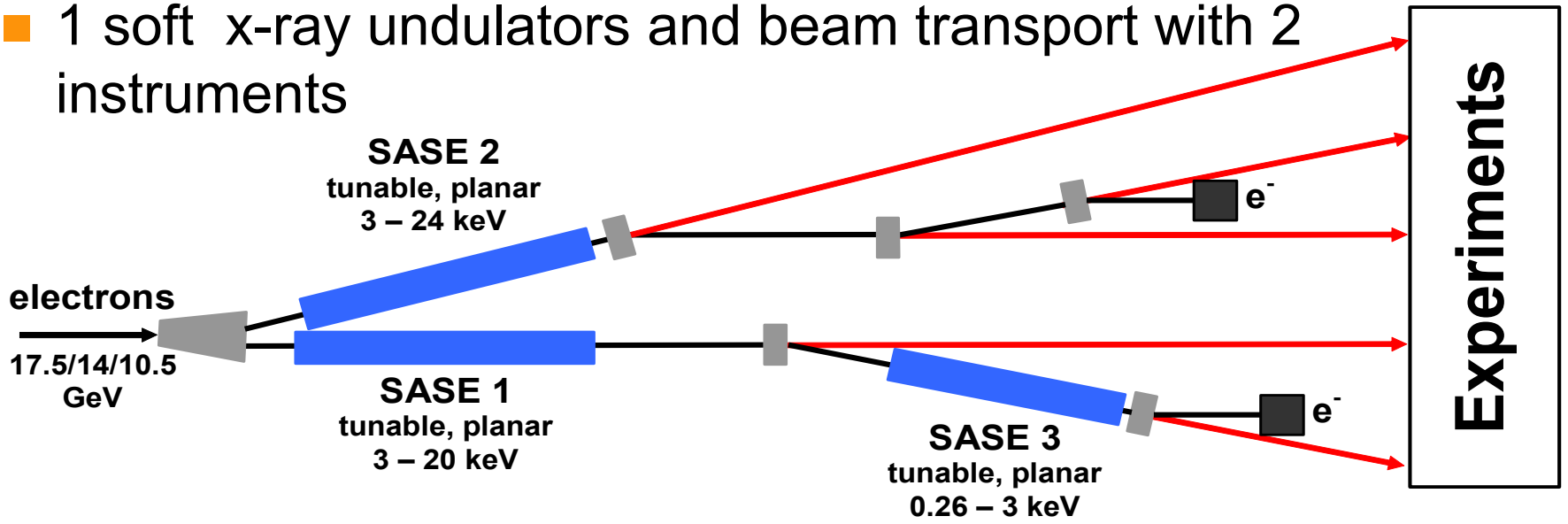
Electron beam properties (simulation)

Table 1: *Electron beam properties as a result of s2e simulations of the electron beam and photon beam properties (W. Decking, M. Dohlus, T. Limberg, I. Zagorodnov, 2010).*

Parameter	Unit	Value					TDR-06
Bunch charge	pC	20	100	250	500	1000	1000
Peak current	kA	4.5	5.0	5.0	5.0	5.0	5.0
Norm. slice emittance (undulator)	10^{-6} m rad	0.32	0.39	0.6	0.7	0.97	1.4
Bunch length (undulator, FWHM)	fs	2.8	15	39	72	180	188
Slice energy spread (laser heater, undulator, rms)	MeV	4.1	2.9	2.5	2.2	2.0	1.0

New x-ray design

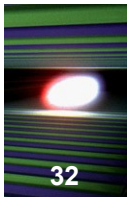
- 2 hard x-ray undulators and beam transport with 4 instruments
- 1 soft x-ray undulators and beam transport with 2 instruments



	Center	Side	Comments
SASE 1	SPB	FXE	
SASE 2	MID	HED	Enable propagation of 25-36 keV radiation; possibly even 60-100 keV
SASE 3	SQS	SCS	Center: Pink beam Side: Monochromatic beam

European XFEL

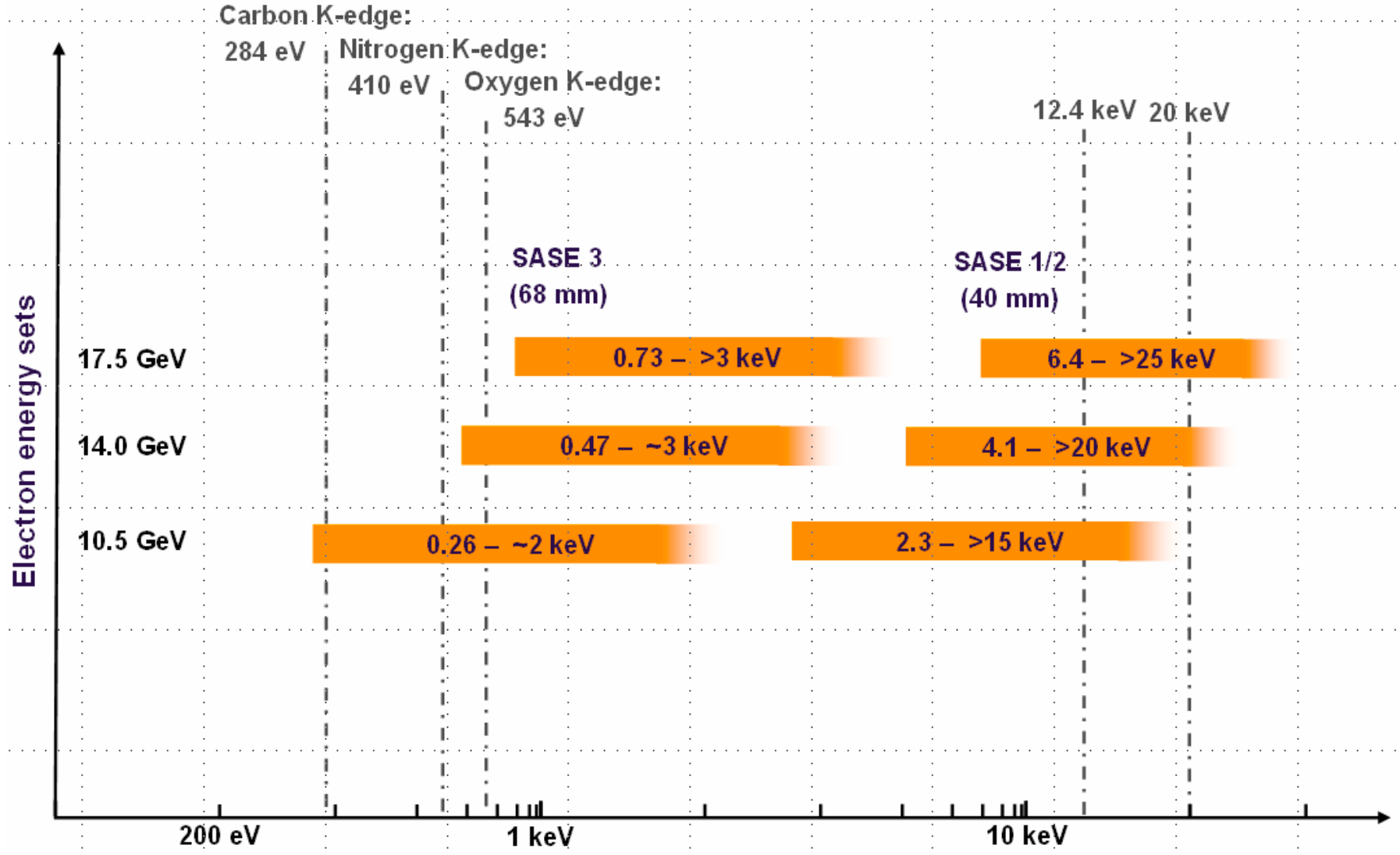
Undulator Parameters



Magnetic gap	Electron energy					
	SASE1 and SASE2 (λ_u=40 mm)			SASE3 (λ_u=68 mm)		
	10.5 GeV	14 GeV	17.5 GeV	10.5 GeV	14 GeV	17.5 GeV
10 mm	2.3 keV	4.1	6.4	0.26	0.47	0.73
12 mm	3.4	6.9	9.3	0.34	0.54	0.84
15 mm	5.5	9.8	15.3	0.45	0.80	1.25
20 mm	10.5	18.7	29.2	0.95	1.68	2.63
24 mm	14.9	26.5	41.4	1.5	2.6	4.1
28 mm	18.6	33.1	51.7	2.2	3.9	6.1

European XFEL

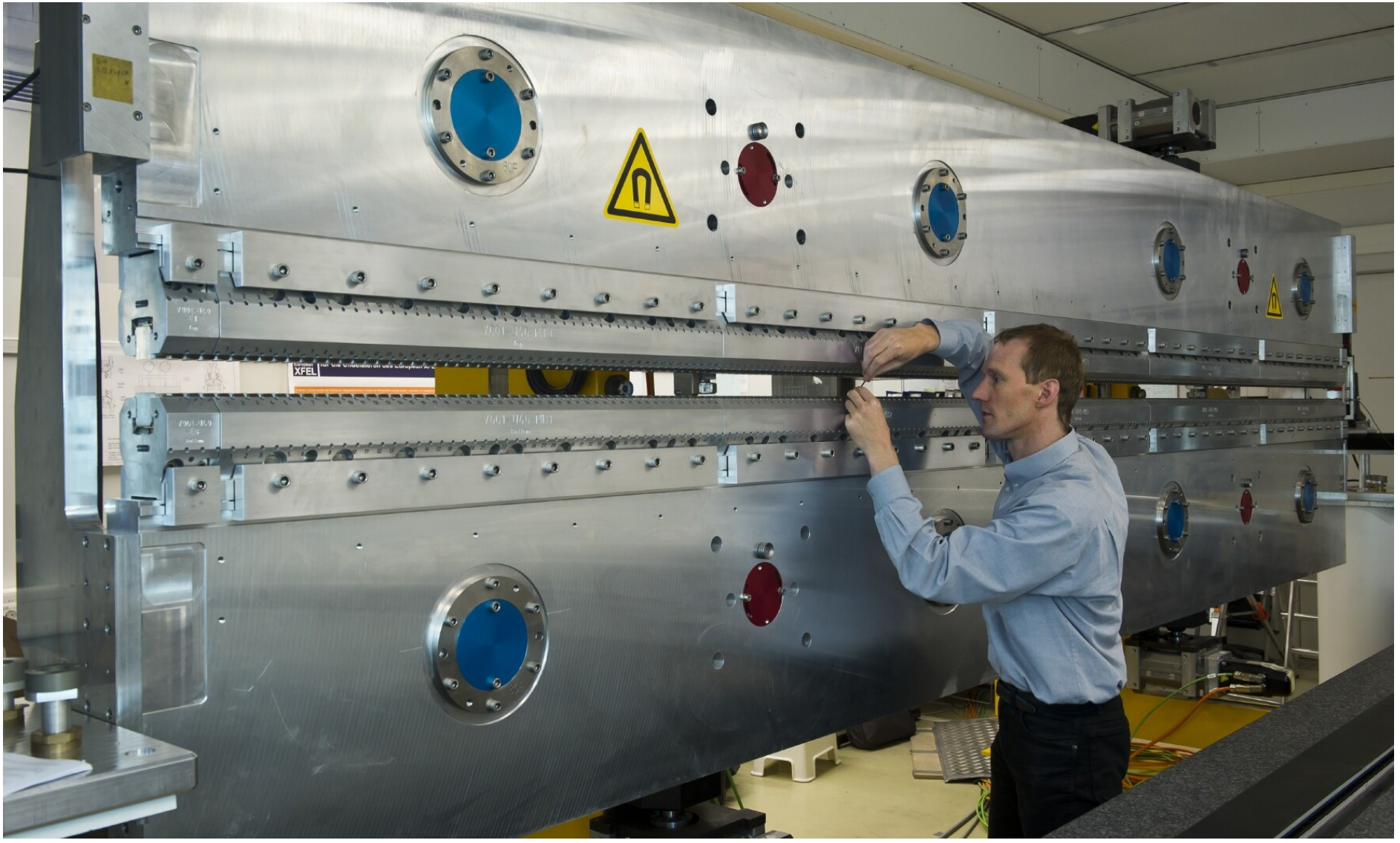
New X-ray Layout : Undulator Ranges



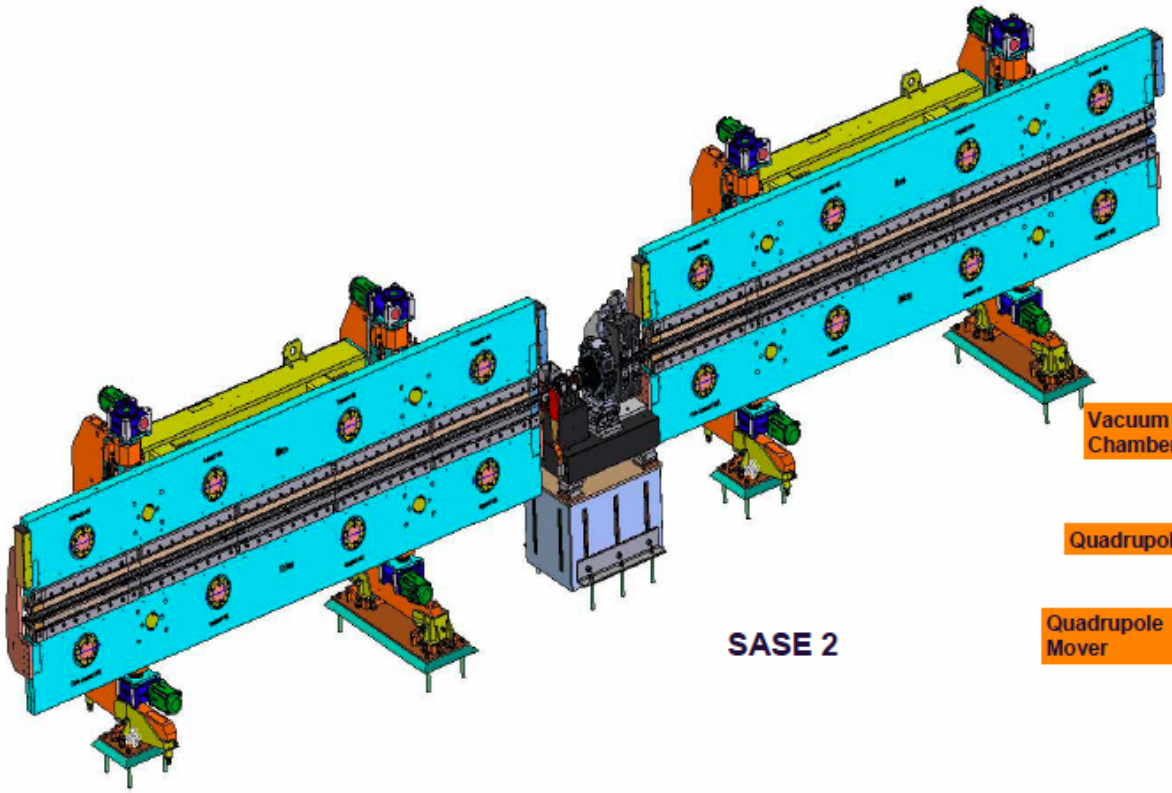
Magnetic measurement labs in building 36

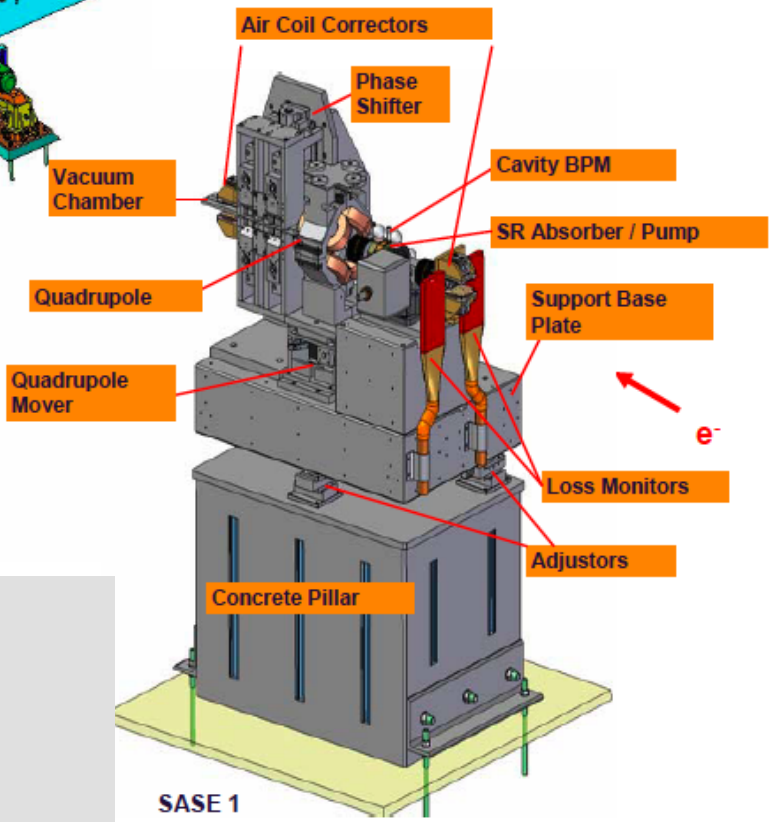
European XFEL

Undulator Prototypes (2nd generation)



Undulator & Intersections (J. Pflüger)





Two generations of prototypes, pre-series, qualification exercises.

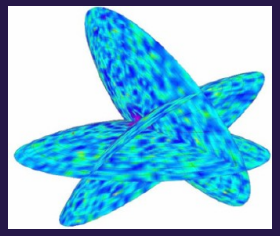
Series CFT concludes early 2012

European XFEL

Scientific instruments: ✓Conc. Design Rev.

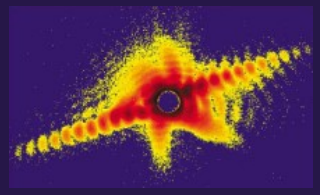
✓**SPB: Ultrafast Coherent Diffraction Imaging of Single Particles, Clusters, and Biomolecules**

Structure determination of single particles: atomic clusters, bio-molecules, virus particles, cells.



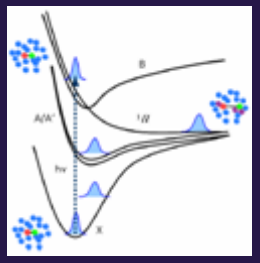
✓**MID: Materials Imaging & Dynamics**

Structure determination of nano-devices and dynamics at the nanoscale.



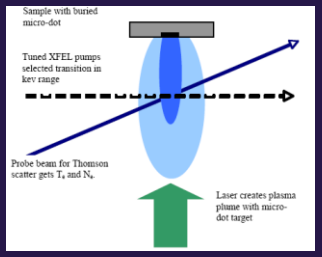
✓**FXE: Femtosecond X-ray Experiments**

Time-resolved investigations of the dynamics of solids, liquids, gases



HED: High Energy Density Matter

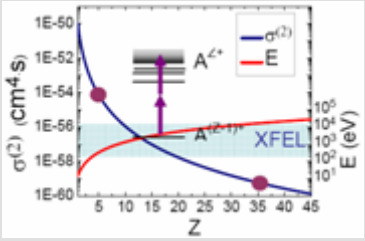
Investigation of matter under extreme conditions using hard X-ray FEL radiation, e.g. probing dense plasmas



Soft x-rays

✓**SQS: Small Quantum Systems**

Investigation of atoms, ions, molecules and clusters in intense fields and non-linear phenomena



SCS: Soft x-ray Coherent Scattering/Spectroscopy

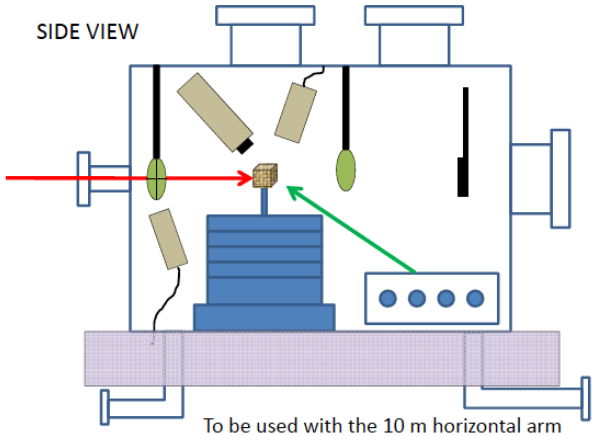
Electronic and real structure, dynamics of nano-systems and of non-reproducible biological objects

European XFEL

Materials Imaging and Dynamics Instrument

Multi-purpose SAXS – WAXS setup

SIDE VIEW



A. Madsen – MID – XFEL.EU

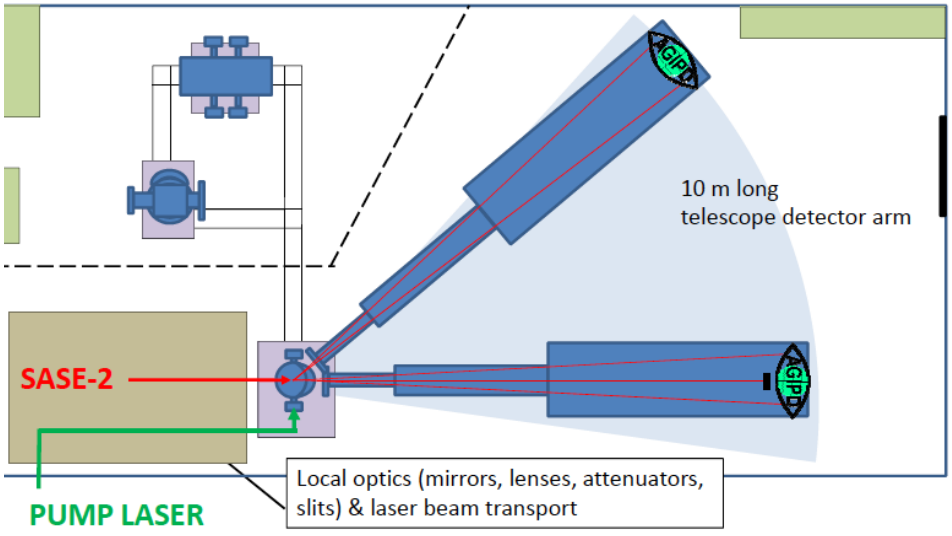
10^{-4} – 10^{-6} mbar

High precision goniometer
Video microscope
Fluorescence det.
I_0 monitor
Alignment tools

Heating/cooling
Electrical connectors
Optical connectors
Fluid connectors
Gas connectors
Laser pump

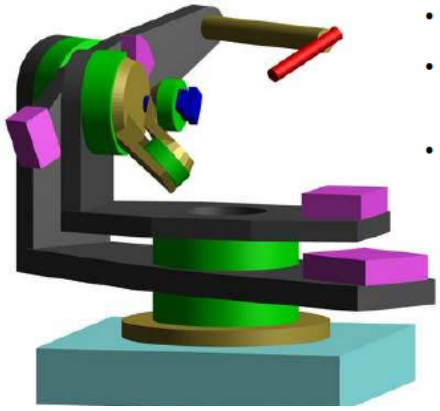
Height adjustment
Movable (on rails)

TOP VIEW



A. Madsen – MID – XFEL.EU

Diffractometer



Flexible design:

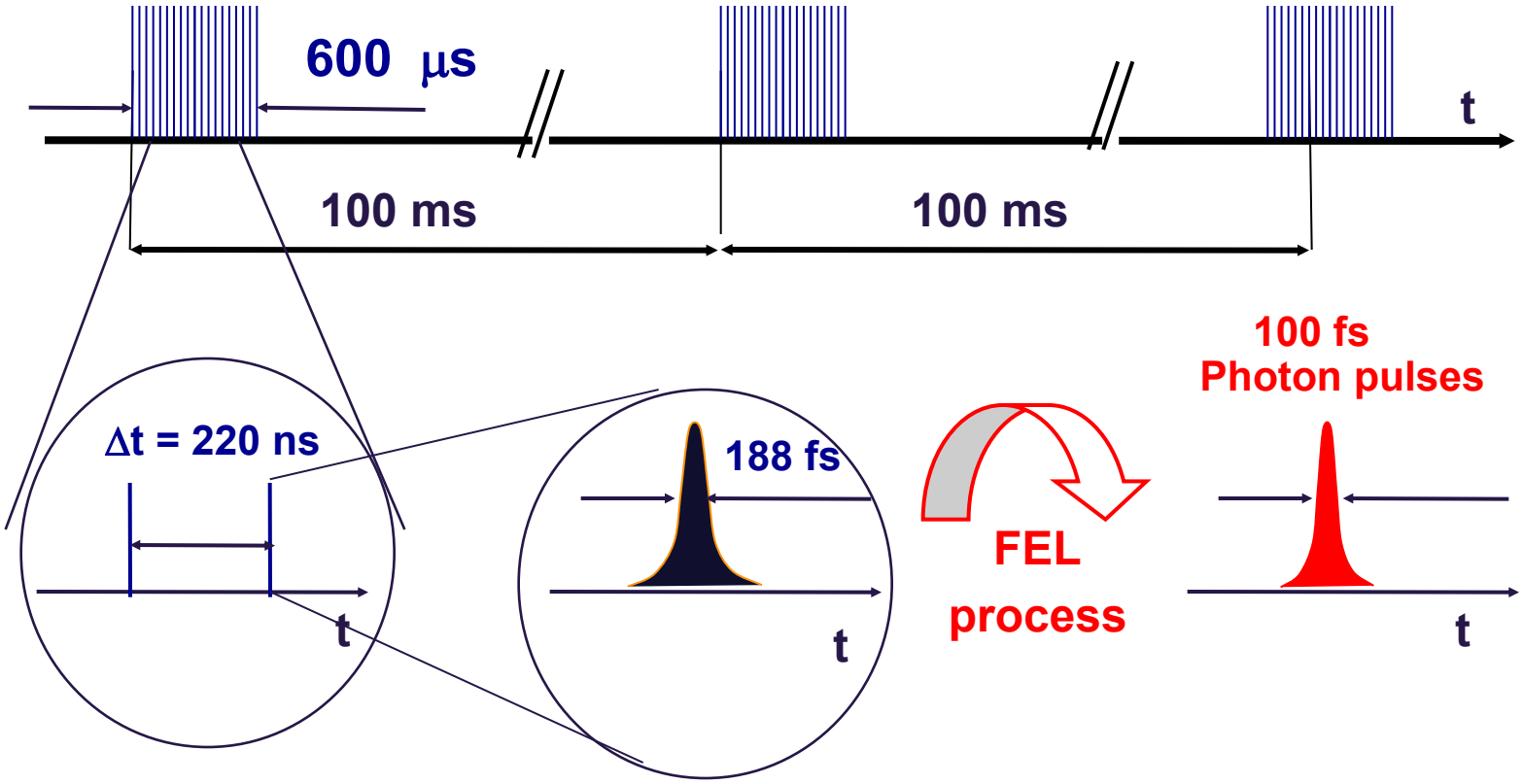
- High load 4 circle geometry (>200 kg load)
- 2+3 circle Kappa geometry (less load but higher flexibility)
- Can also be used together with 10m long horizontal arm

Challenges: proper counterweighting with long arm and detector, positioning precision,...

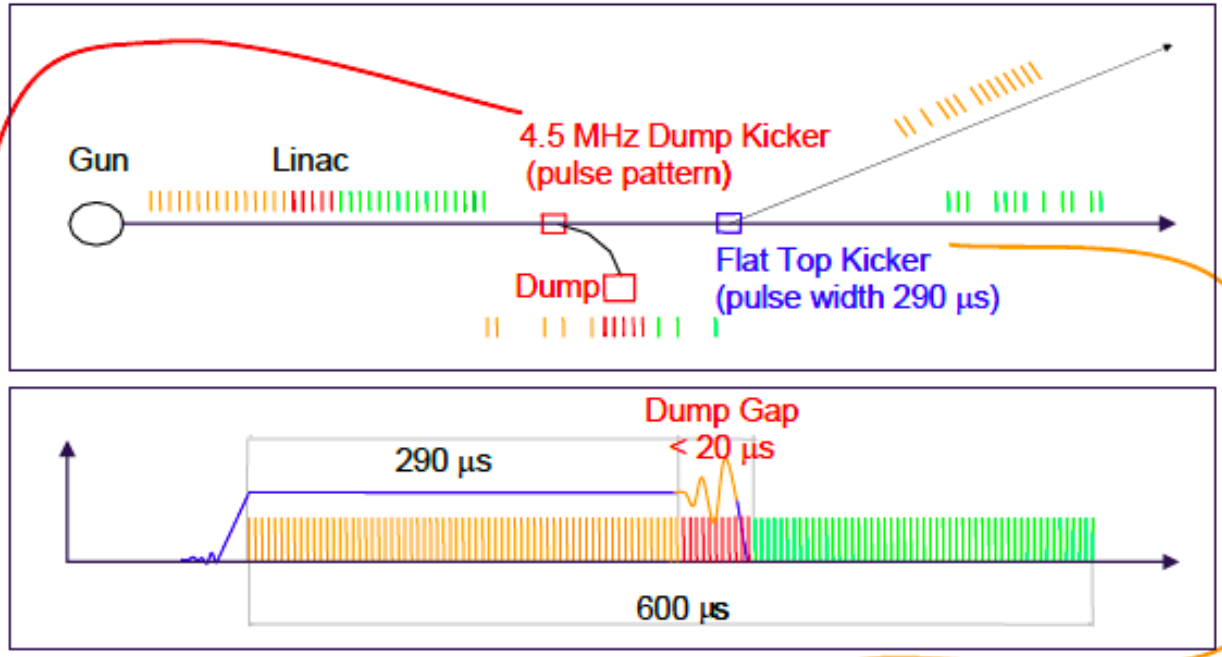
Conceptual Design Report by Anders Madsen, discussed with SAC in September 2011

European XFEL Project—Time Structure

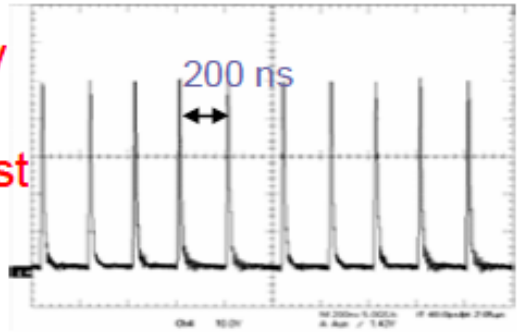
Electron bunch trains
(with up to 2700 bunches à 1 nC)



Beam Switchyard

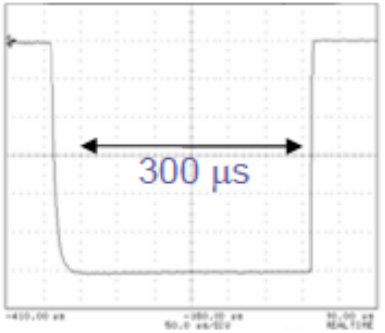


- low accuracy (>1 %)
- 4.5 MHz burst operation



example:
pulser prototype measurement

- high accuracy (< 0.01 %)
- 10 Hz operation



example:
pulser prototype measurement

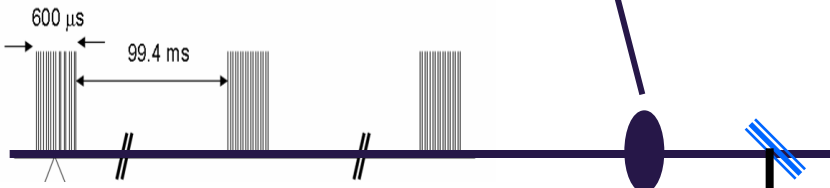
High repetition rate challenges

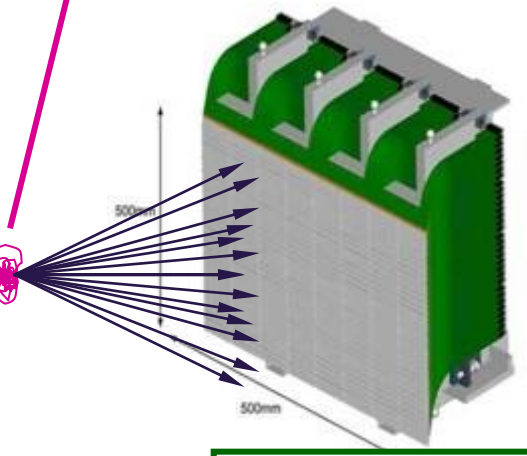
Sample Env. Group, J. Schulz

Optics Group, H. Sinn

X-ray optics
- withstand repetition rate
- exhibit high accuracy

Sample delivery
- match repetition rate
- positioning





Photon diagnostics
- on-line & single-shot
- match repetition rate

Diagnostics group, J. Grünert

Optical laser
- match repetition rate
- provide ~mJ excitation energy

Laser Group, M. Lederer

Detectors
- match frame rate
- large data amounts

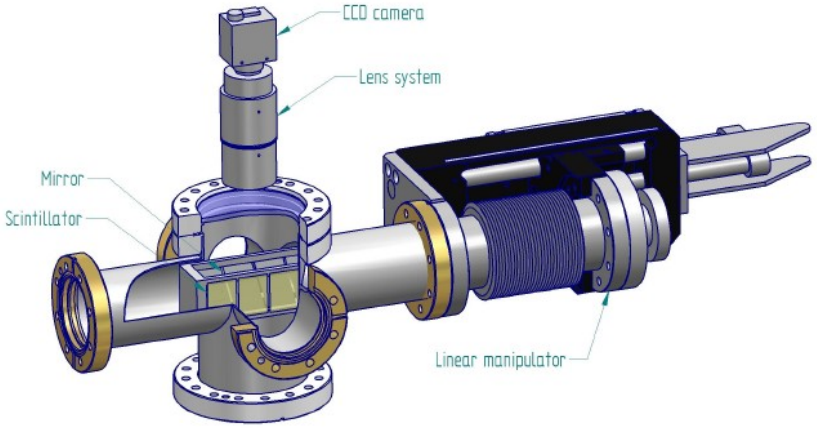
Detector Group, M. Kuster

Courtesy Th. Tschentscher

High repetition rate challenges

- Optics, CDR passed, see talk later today
- Data Acquisition, talk later

- Diagnostics, CDR in progress (20.January 2012)



➔ Strong collaboration with DESY/Hasylab (Gas Monitors successfully tested at SACLA)

Laser Group Activities

- Laser Group: 4 scientist/engineers already here; move to building 49d in March 2012
- Launched industrial collaboration R&D project: „20kW, 10Hz burst-mode InnoSlab Yb:YAG booster amplifier“
- Take delivery of all-fibre front-end amplifier in March 2012
  - Verify and review performance
    - ➔ Compare performance with simulation results
    - ➔ Characterise supercontinuum from various crystals
  - Implement NOPA pumped by all-fibre front-end
  - Finalise NOPA-simulations and compare predictions with experiments
- Report to LAC in March 2012
- Start work on sub-systems (PC-Slicer, beam pointing and timing drift stabilisation, dispersion management for beam delivery)
- System layout of R&D pump-probe laser

Detector Developments

AGIPD Adaptive Gain Integrating Pixel Detector Consortium (AGIPD)

Project Leader:

H. Graafsma, DESY

- PSI/SLS Villingen
- Universität Bonn
- Universität Hamburg
- DESY

Radiation Damage Studies

Project Finished

Project Leader:

R. Klanner, Universität Hamburg

Charge Cloud Studies

Project Finished

Project Leader:

K. Gärtner, Weierstrass Institut Berlin

Large Pixel Detector Consortium (LPD)

Project Leader:

M. French, RAL/STFC

- Rutherford Appleton Laboratory/STFC
- University of Glasgow

DEPFET Sensor with Signal Compression Consortium (DSSC)

Project Leader:

M. Porro, Politecnico di Milano

- Max-Planck Halbleiterlabor Munich
- Universität Heidelberg
- Universität Siegen
- Politecnico di Milano
- Università di Bergamo
- DESY Hamburg

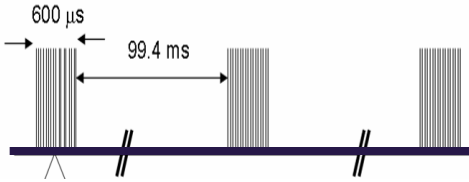
High repetition rate challenges

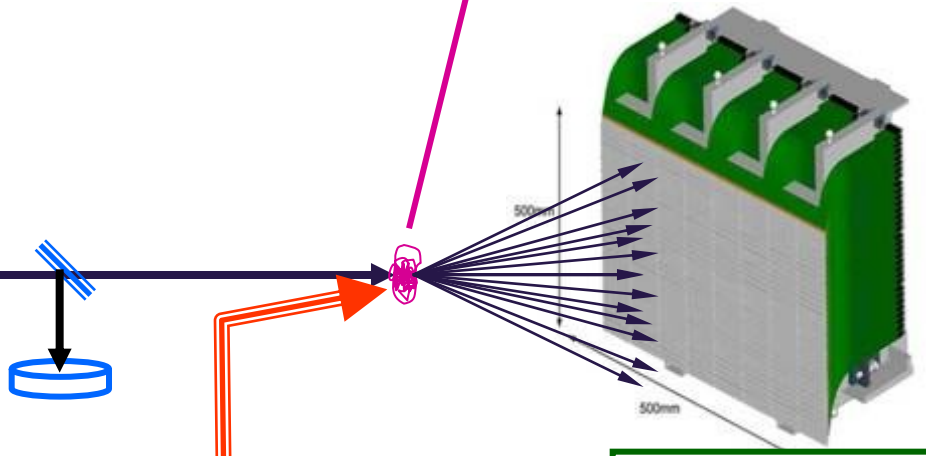
Sample Env. Group, J. Schulz

Optics Group, H. Sinn

X-ray optics
- withstand repetition rate
- exhibit high accuracy

Sample delivery
- match repetition rate
- positioning





Photon diagnostics
- on-line & single-shot
- match repetition rate

Diagnostics group, J. Grünert

Optical laser
- match repetition rate
- provide ~mJ excitation energy

Laser Group, M. Lederer

Detectors
- match frame rate
- large data amounts

Detector Group, M. Kuster

Courtesy Th. Tschentscher

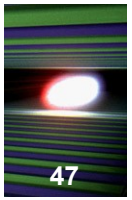
Contributions by Users Consortia

- The European XFEL decided to invite User Consortia (UC) to submit Expressions of Interest (EoI) to contribute to, and to collaborate in, the construction of the scientific instruments for the European XFEL.

- A call for informal Expressions of Interest (EoI) was issued. All interested users are invited to describe scientific objectives, basic technical aspects and a schematic indication of the resources they could make available.

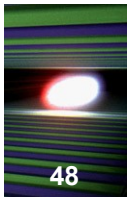
- Deadline: 15 June, 2011

Results of the call for Expressions of Interest



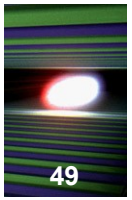
- We received 9 Expressions of Interest (EoI), by the June 15 deadline, in which overall more than 110 M€ of contributions are envisaged (but by no means secured!!).
- The majority of the proposed contributions is beyond the baseline instrumentation scope.
- There are extremely valuable contributions to the success of the European XFEL among the proposed EoI's.

Proposed Contributions



- Support to structural biology: Bio-labs in an adjacent building, expansion of computational capabilities, a station for Nanocrystallography on a hard X-ray branch, additional lasers systems
- A Petawatt laser and transport system for the High Energy Density Instrument
- Additional versatile experimental chambers and detectors
- A RIXS station for the soft X-ray branch
- A helical afterburner, to produce variable polarization soft X-rays

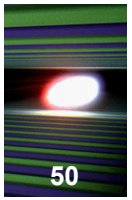
Proposed contributions



- **FULL PROPOSALS REQUESTED FOR MARCH 15, 2012**
- **EVALUATION INVOLVING SAC, DECISION BY COUNCIL**

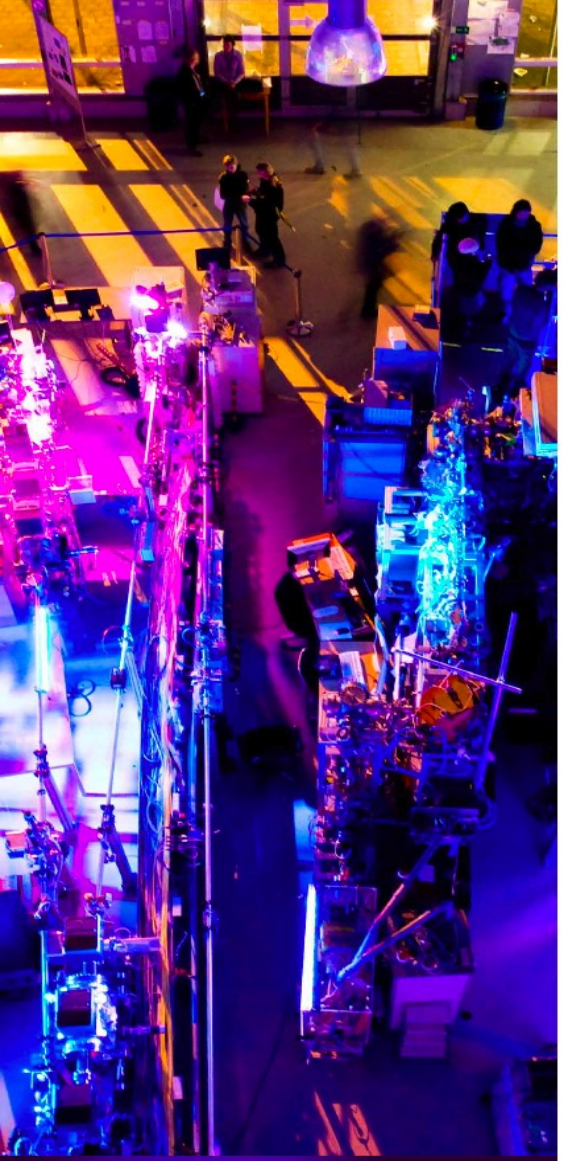
Rules of the game: One day of reserved beam time (to be used in the first three years) for every 270,000 € of investment. All remaining beamtime: open access with peer review.

Last but not least



- It is very important for our scientists to acquire first-hand experience not only on FLASH, but especially on LCLS, and soon SACLA, FERMI…

- See talk by W. Gawelda tomorrow, posters



SCIENCE at FELs.

SRI 2012 Satellite Meeting

15 – 18 July, 2012
at DESY in Hamburg, Germany

jointly organised by DESY and European XFEL

The Science at FELs Satellite Meeting to the 11th International Conference on Synchrotron Radiation Instrumentation in Lyon, France will present science highlights achieved in the first seven years of operation of short-wavelength Free-Electron Lasers (FELs). Applications from quantum optics to life sciences and systems from atoms to complex solids will be featured. A focus will also be placed on new directions in science at FELs and challenges to scientific instrumentation. Hamburg is directly connected to Lyon via airplane. Visits of the **FLASH** facility at DESY and the **European XFEL** construction site will be included in the meeting programme.

International programme committee
M. Altarelli (European XFEL), H. Dosch (DESY), T. Ishikawa (RIKEN SPring-8), F. Parmigiani (University of Trieste), C. Pellegrini (UCLA), J. Stöhr (SLAC)

Local organising committee
E. Weckert (chair), J. Feldhaus, E. Plönjes (DESY) Th. Tschentscher (chair), I. Gembalies, A. Madsen, M. Meyer (European XFEL)

For registration and programme information please visit:
science-at-FELs-2012.desy.de

Deadline for abstract submission is 30 January 2012.

SRI2012

DESY

European XFEL

Thank you for your attention!