



# Status of the European XFEL Project

**Massimo Altarelli**

*European XFEL Project Team Leader*

*DESY, Hamburg*

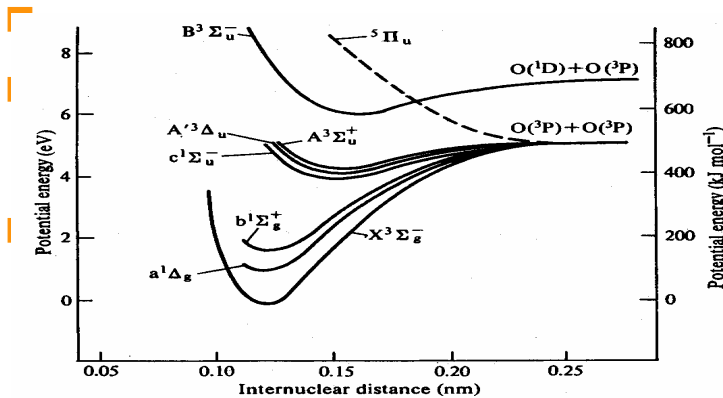
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# Wanted...A more brilliant X-ray source, with:

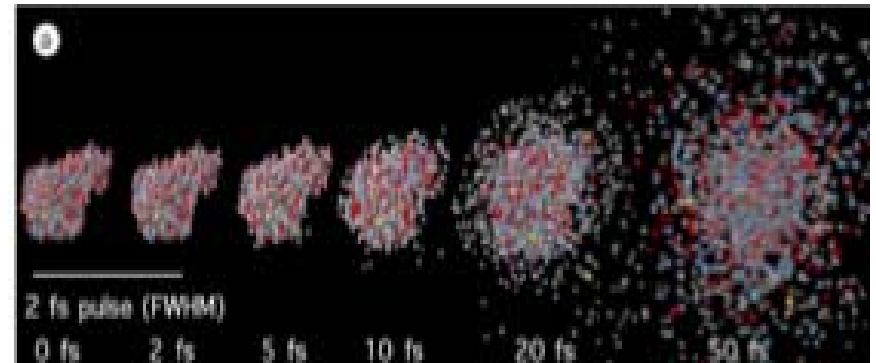
2

wavelength down to  $\sim 0.1$  nm  $\Rightarrow$  atomic-scale resolution

ultrashort ( $<1$  ps) pulses  
 $\Rightarrow$  “molecular movies”



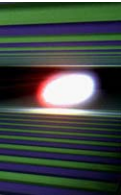
ultra-high peak brightness  
 $\Rightarrow$  investigation of matter  
under extreme conditions...



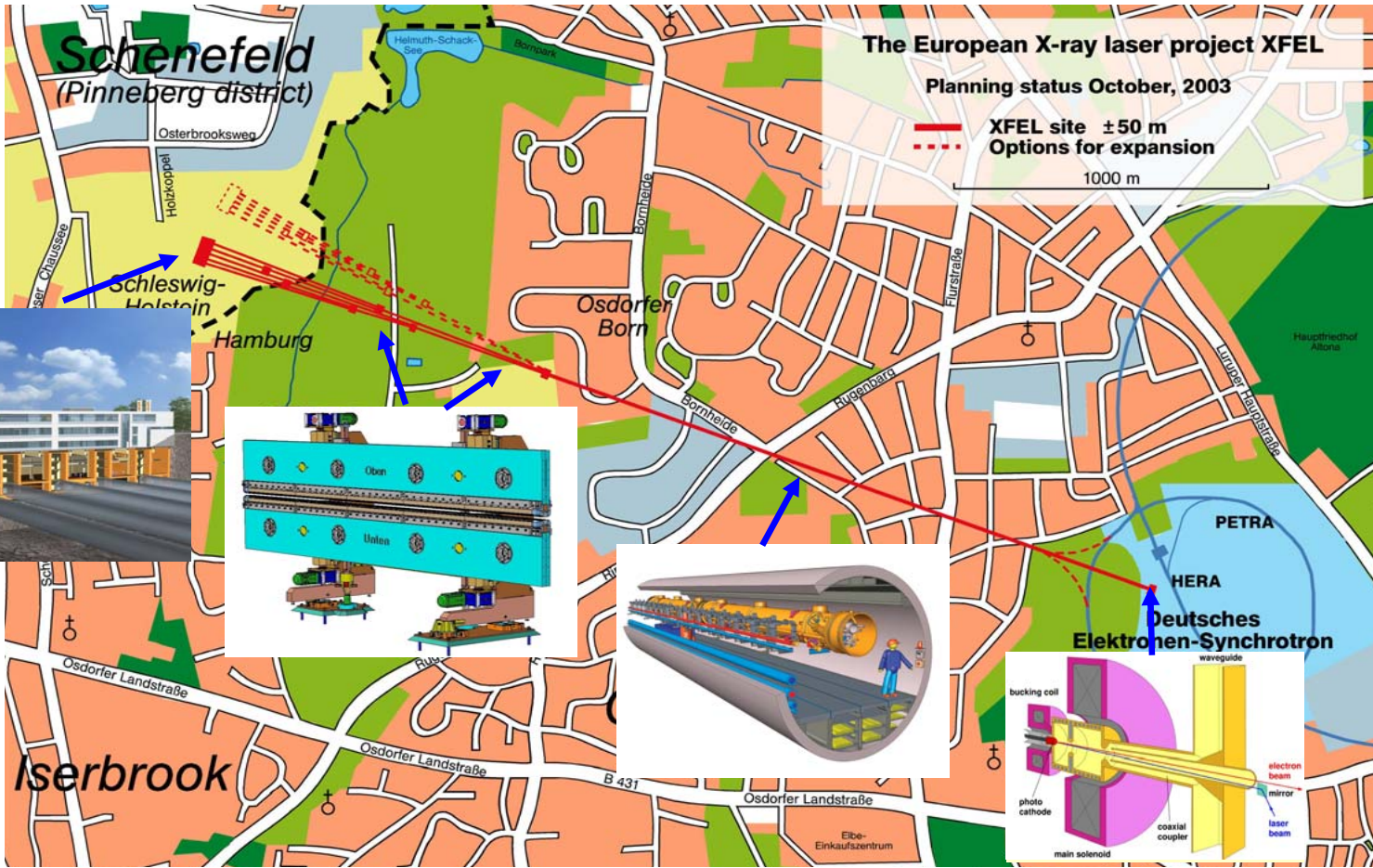
transverse spatial coherence

$\Rightarrow$  imaging of single nanoscale objects, possibly down to individual macromolecules (no crystals)

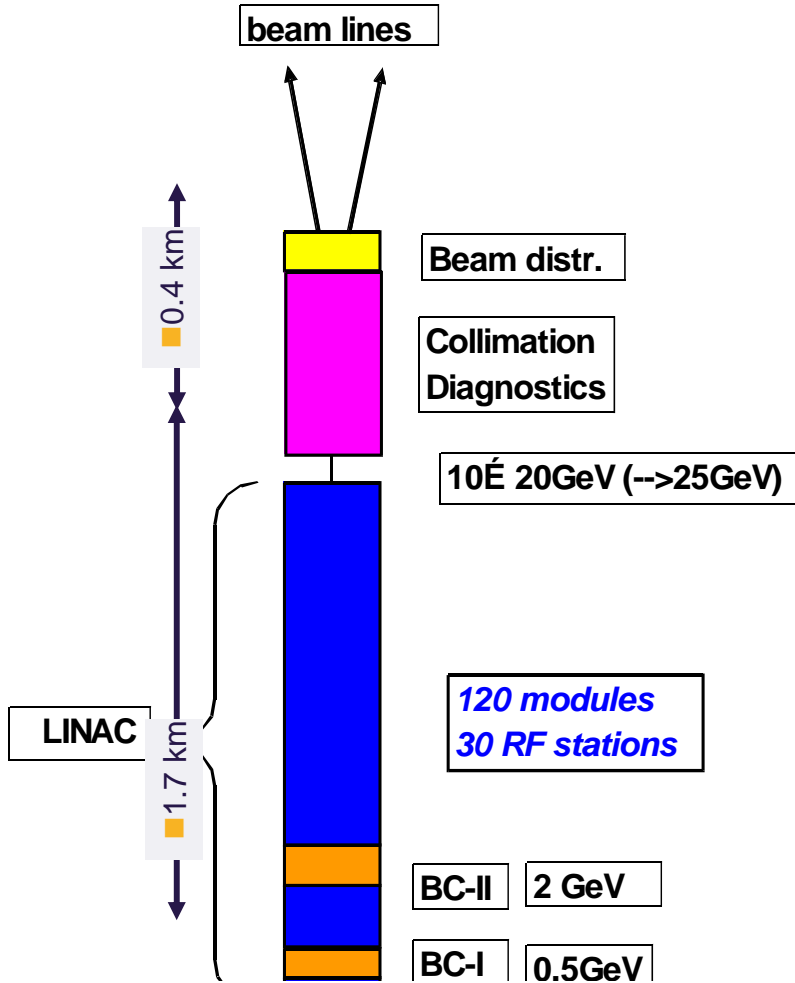
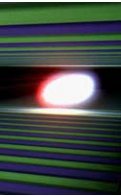
# Overall layout of the European XFEL



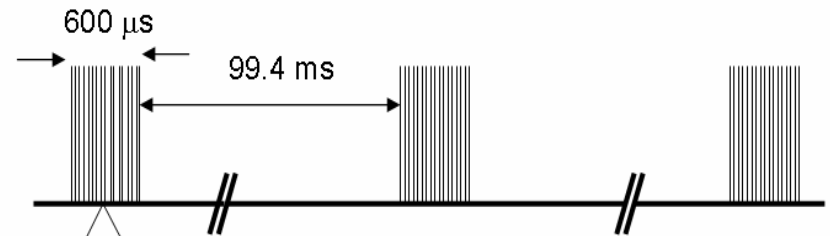
← 3.4km →

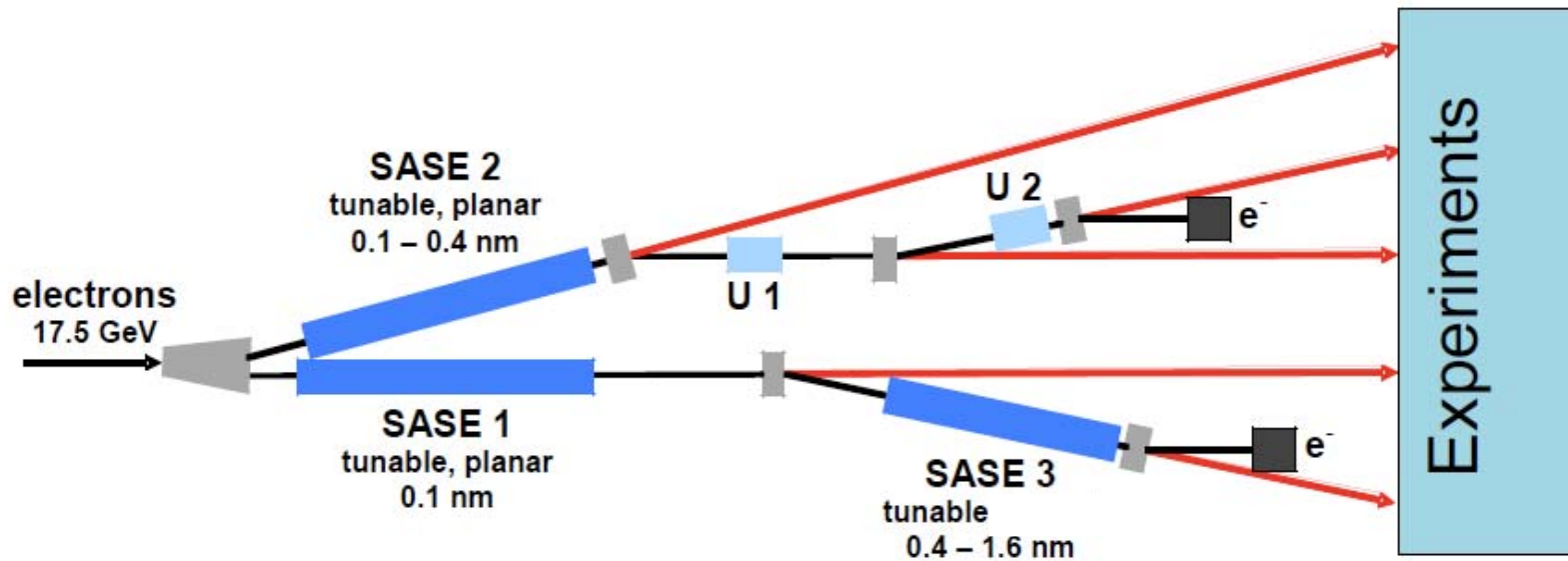
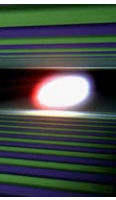


# Schematic Accelerator Layout



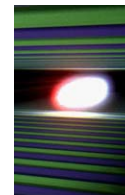
Parameter	Unit	Value
Electron energy for 0.1 nm FEL radiation	GeV	17.5
Accelerating gradient	MeV/m	22.9
Bunch charge	nC	1
RF pulse repetition rate	Hz	10
Electron bunch repetition rate during RF pulse	MHz	5
Max. number of electron bunches per RF pulse		3000
Duration of electron	$\mu$ s	600
Average electron beam power	kW	570
Normalized slice emittance (rms)	mm mrad	1.4
Electron energy spread (rms)	MeV	< 1





Initial configuration: SASE1, SASE2, SASE3 (planar)  
plus six instruments

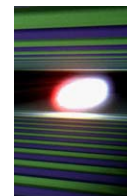
# Photon Beam Parameters



Parameter	Unit	SASE 1	SASE 2		SASE 3		
Electron energy	GeV	17.5	17.5	17.5	17.5	17.5	10.0**
Wavelength	nm	0.1	0.1	0.4	0.4	1.6	6.4
Photon energy	keV	12.4	12.4	3.1	3.1	0.8	0.2
Peak power	GW	20	20	80	80	130	135
Average power*	W	65	65	260	260	420	580
Photon beam size (FWHM)	μm	70	85	55	60	70	95
Photon beam divergence (FWHM)	μrad	1	0.84	3.4	3.4	11.4	27
Coherence time	fs	0.2	0.22	0.38	0.34	0.88	1.9
Spectral bandwidth	%	0.08	0.08	0.18	0.2	0.3	0.73
Pulse duration	fs	100	100	100	100	100	100
Photons per pulse	#	10 <sup>12</sup>	10 <sup>12</sup>	1.6 × 10 <sup>13</sup>	1.6 × 10 <sup>13</sup>	1.0 × 10 <sup>14</sup>	4.3 × 10 <sup>14</sup>
Average flux	#/s	3.3 × 10 <sup>16</sup>	3.3 × 10 <sup>16</sup>	5.2 × 10 <sup>17</sup>	5.2 × 10 <sup>17</sup>	3.4 × 10 <sup>18</sup>	1.4 × 10 <sup>19</sup>
Peak brilliance	B	5.0 × 10 <sup>33</sup>	5.0 × 10 <sup>33</sup>	2.2 × 10 <sup>33</sup>	2.0 × 10 <sup>33</sup>	5.0 × 10 <sup>32</sup>	0.6 × 10 <sup>32</sup>
Average brilliance*	B	1.6 × 10 <sup>25</sup>	1.6 × 10 <sup>25</sup>	7.1 × 10 <sup>24</sup>	6.4 × 10 <sup>24</sup>	1.6 × 10 <sup>24</sup>	2.0 × 10 <sup>23</sup>



# Selection of first instruments

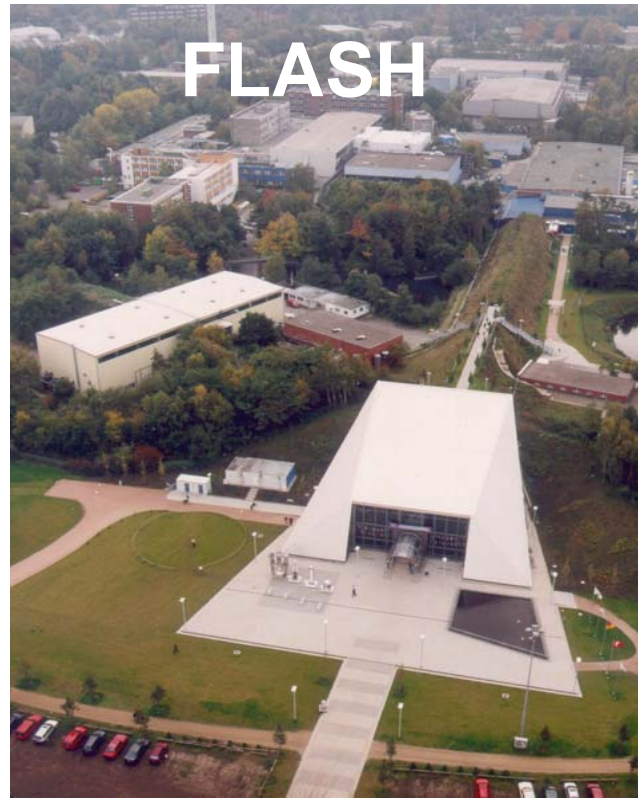
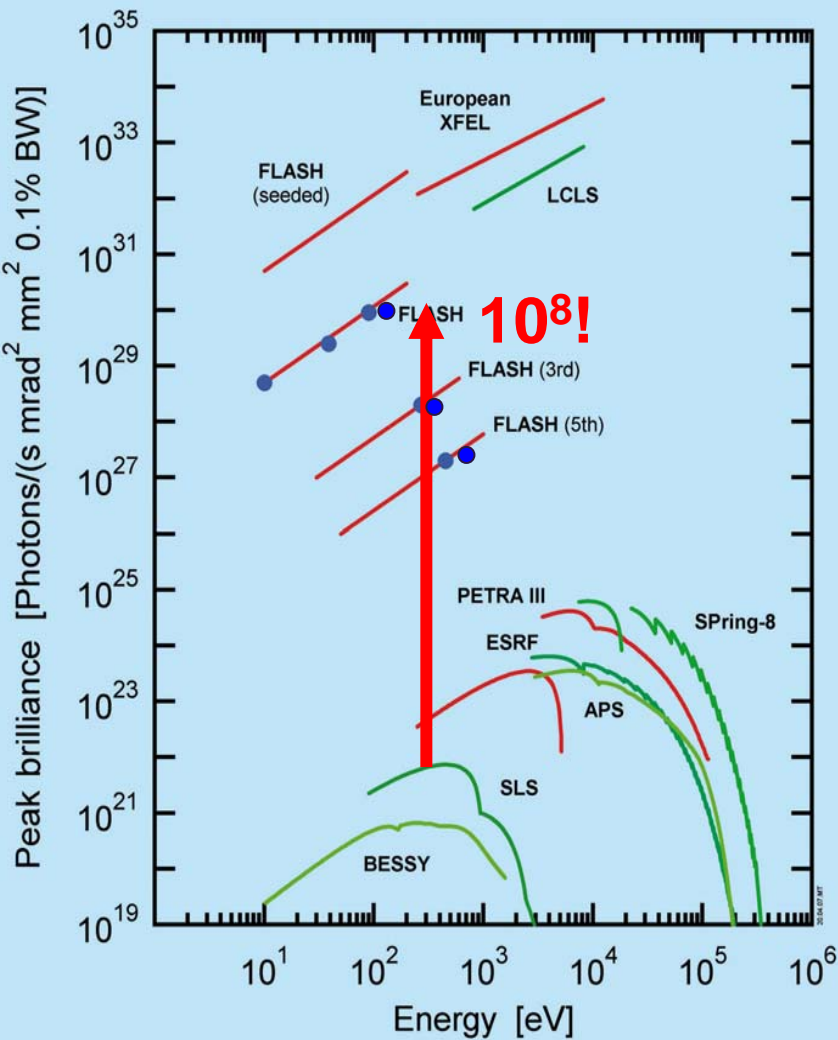
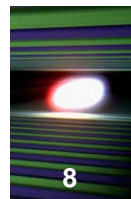


Instrument	Brief description of the instrument
SPB	Ultrafast Coherent Diffraction Imaging of Single Particles, Clusters, and Biomolecules – <b>Structure determination of single particles: atomic clusters, bio-molecules, virus particles, cells.</b>
MID	Materials Imaging & Dynamics – <b>Structure determination of nano-devices and dynamics at the nanoscale.</b>
FDE	Femtosecond Diffraction Experiments – <b>Time-resolved investigations of the dynamics of solids, liquids, gases</b>
HED	High Energy Density Matter – <b>Investigation of matter under extreme conditions using hard x-rays, e.g. probing dense plasmas.</b>
SQS	Small Quantum Systems – <b>Investigation of atoms, ions, molecules and clusters in intense fields and non-linear phenomena.</b>
SCS	Spectroscopy and Coherent Scattering – <b>Structure and dynamics of nano-systems and of non-reproducible biological objects using soft X-rays.</b>

Hard X-rays

Soft X-rays

# Comparison of 3rd and 4th generation sources

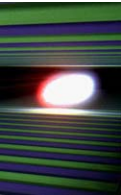


The first SASE FEL operating in the soft X-rays, down to 6.5 nm (+3rd, 5th harmonic!)

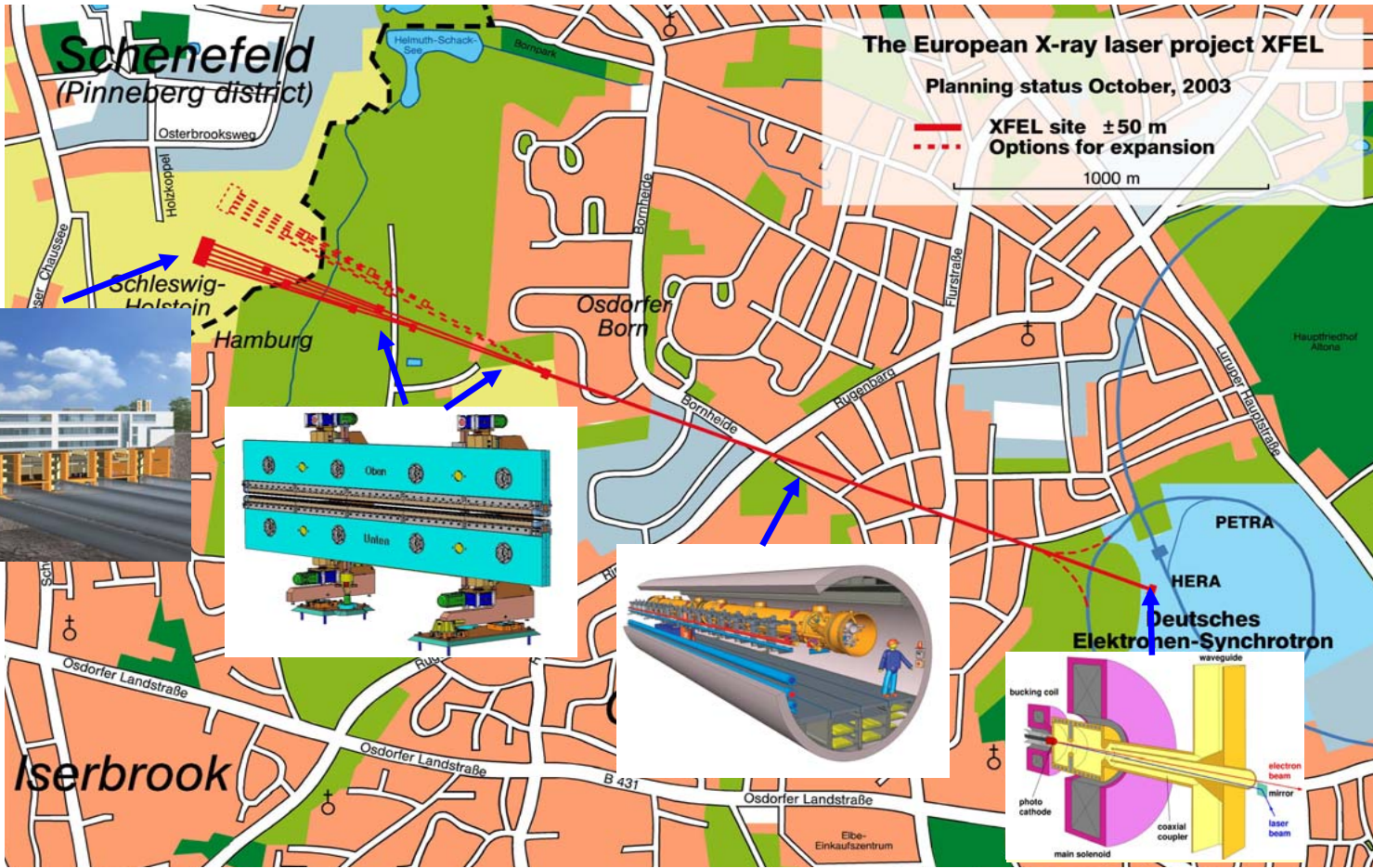
1 GeV Superconducting Linear Accelerator



# Overall layout of the European XFEL

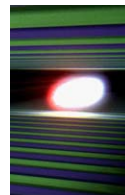


← 3.4km →



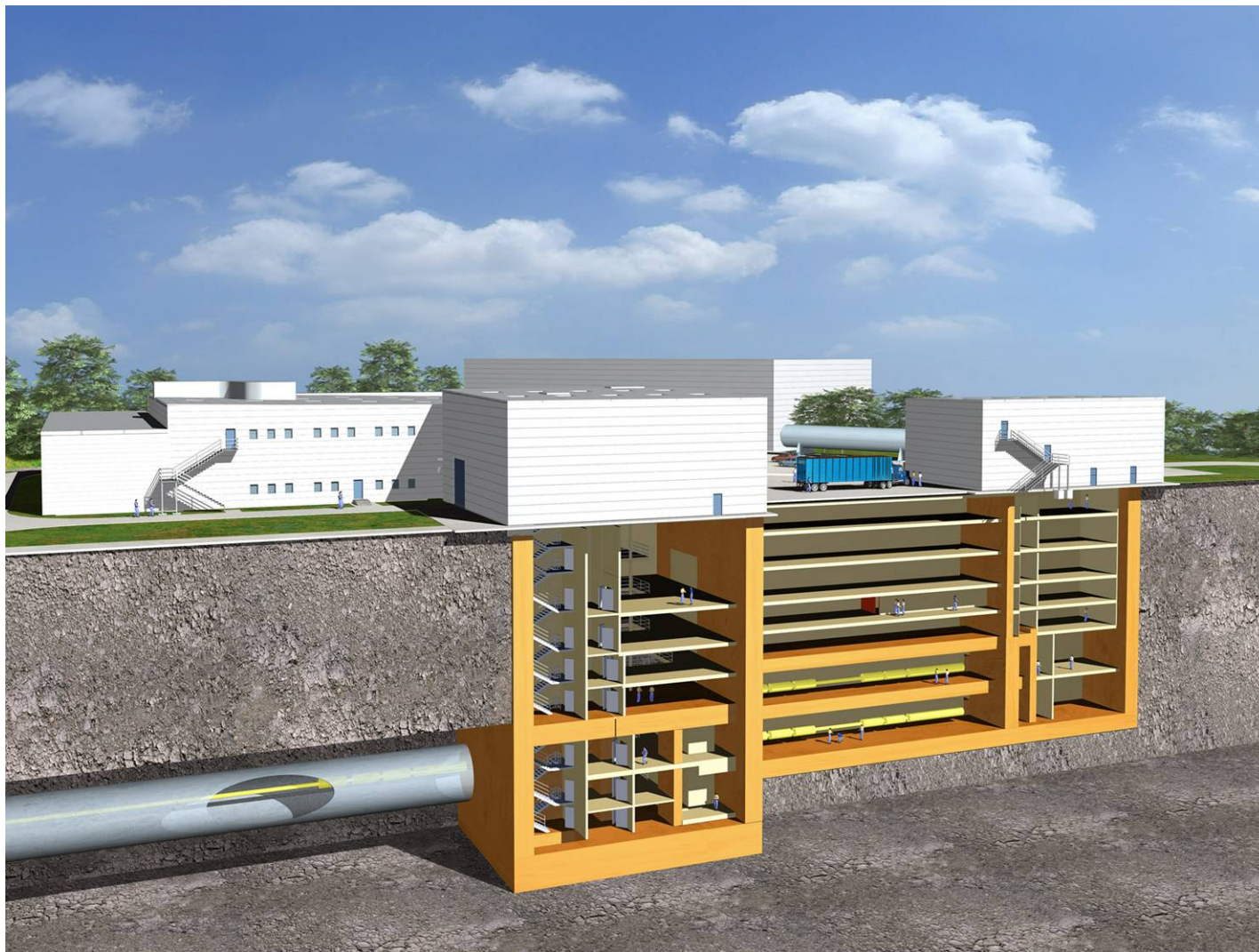
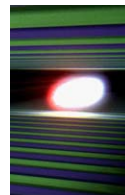


# DESY Bahrenfeld Site – Computer Simulation

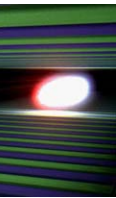




# DESY Bahrenfeld Site – Injector Complex



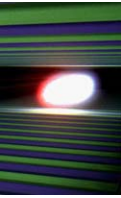
# DESY-Bahrenfeld Site



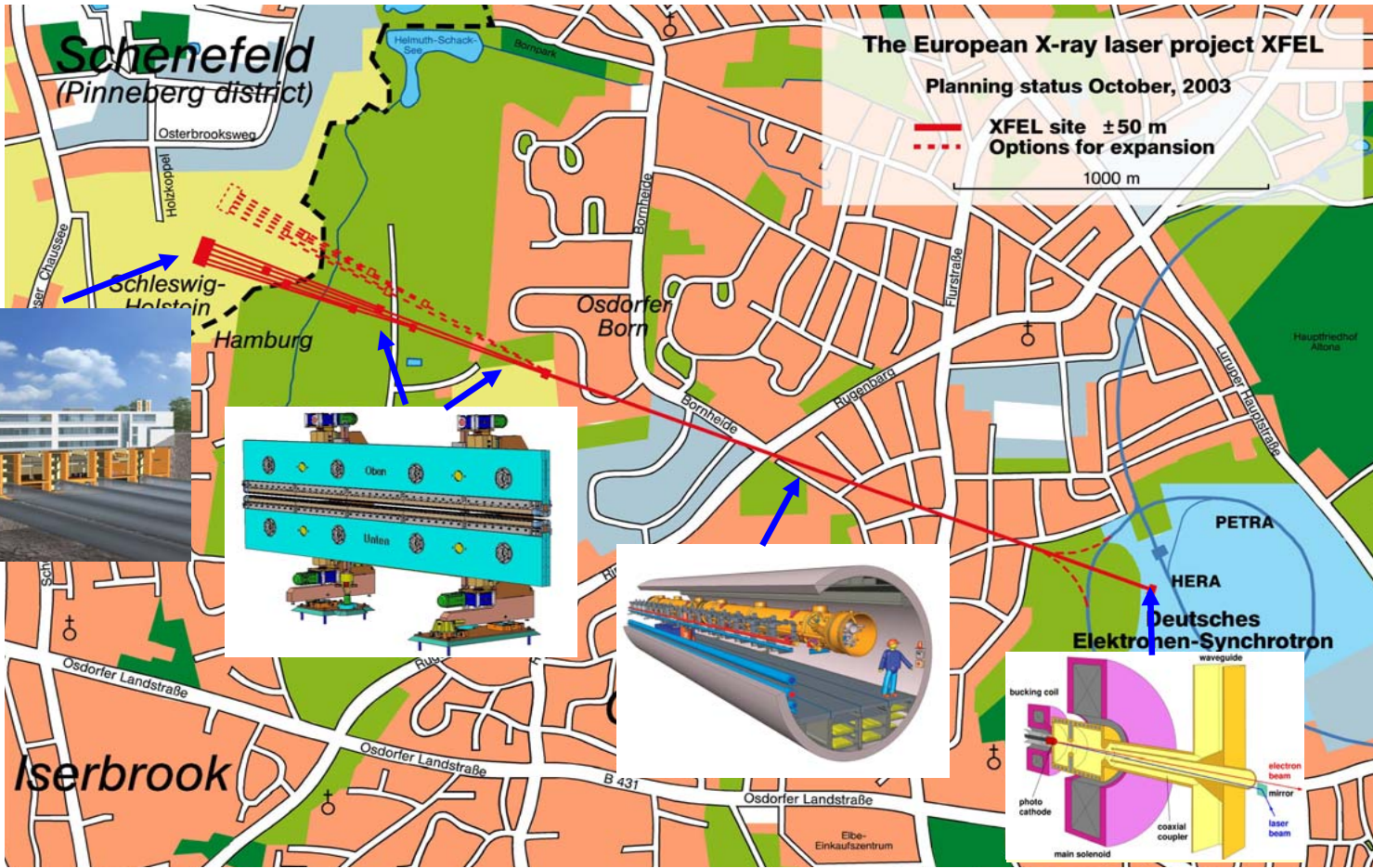
06.05.2009 - 17:27



# Overall layout of the European XFEL

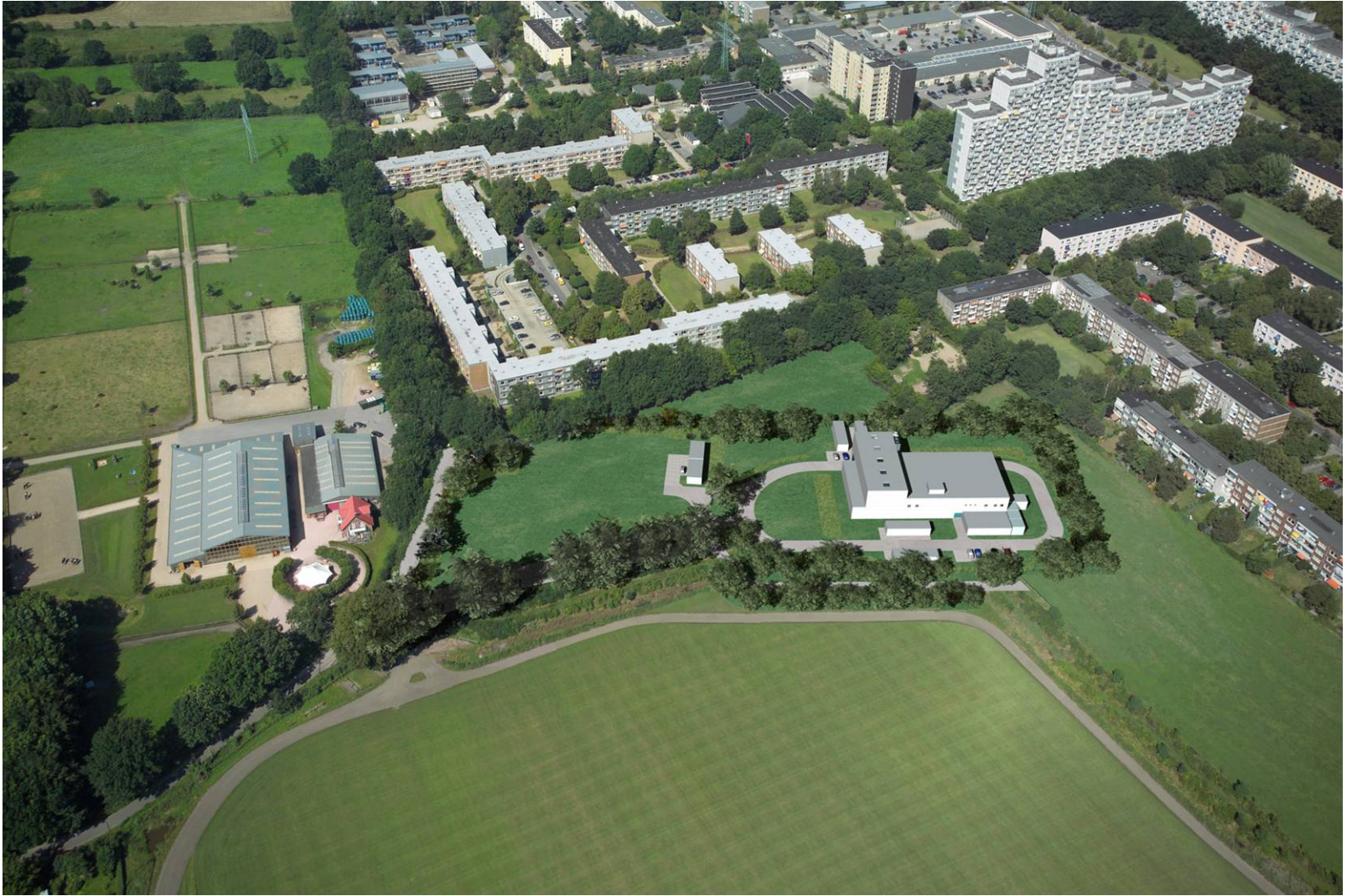
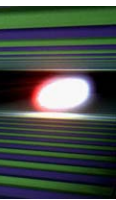


← 3.4km →



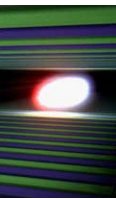


# Osdorfer Born Site – Computer Simulation



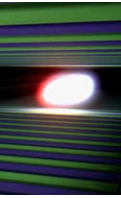


# Osdorfer Born Site

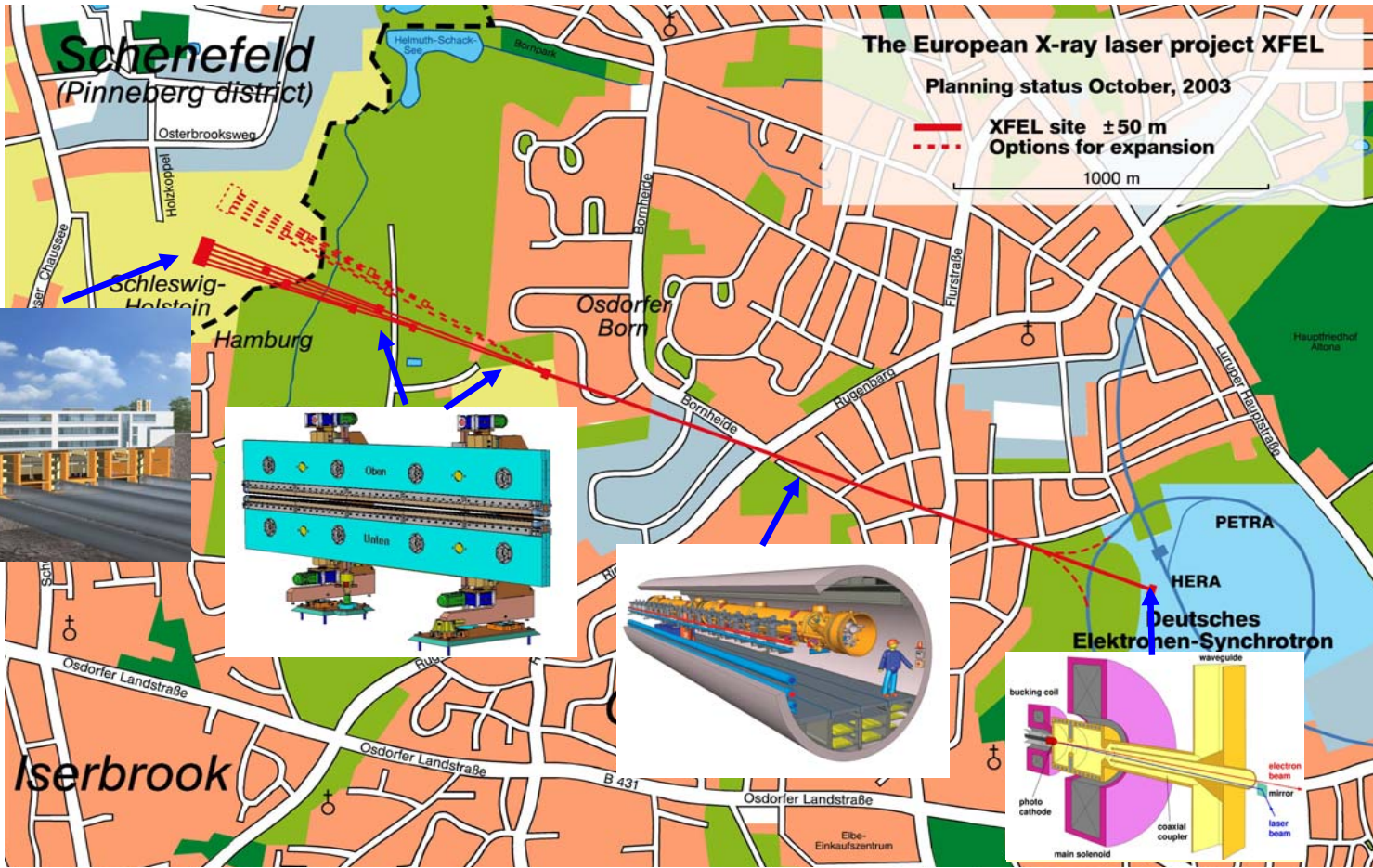


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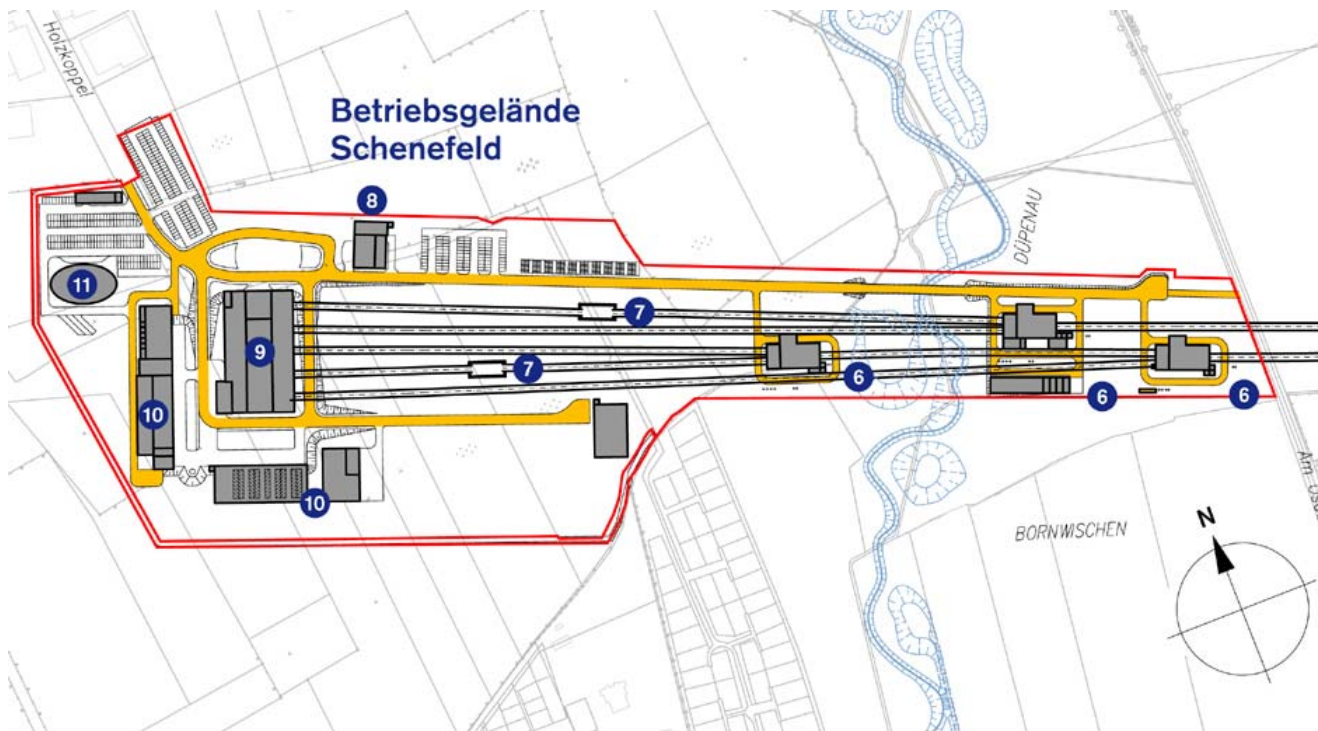
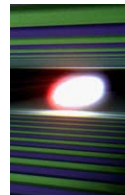
# Overall layout of the European XFEL



← 3.4km →





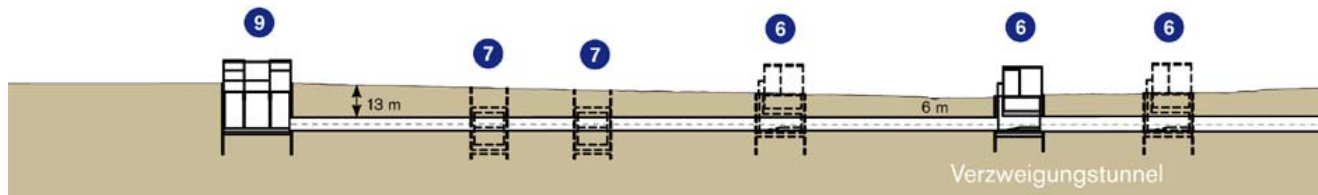


Distribution Shafts

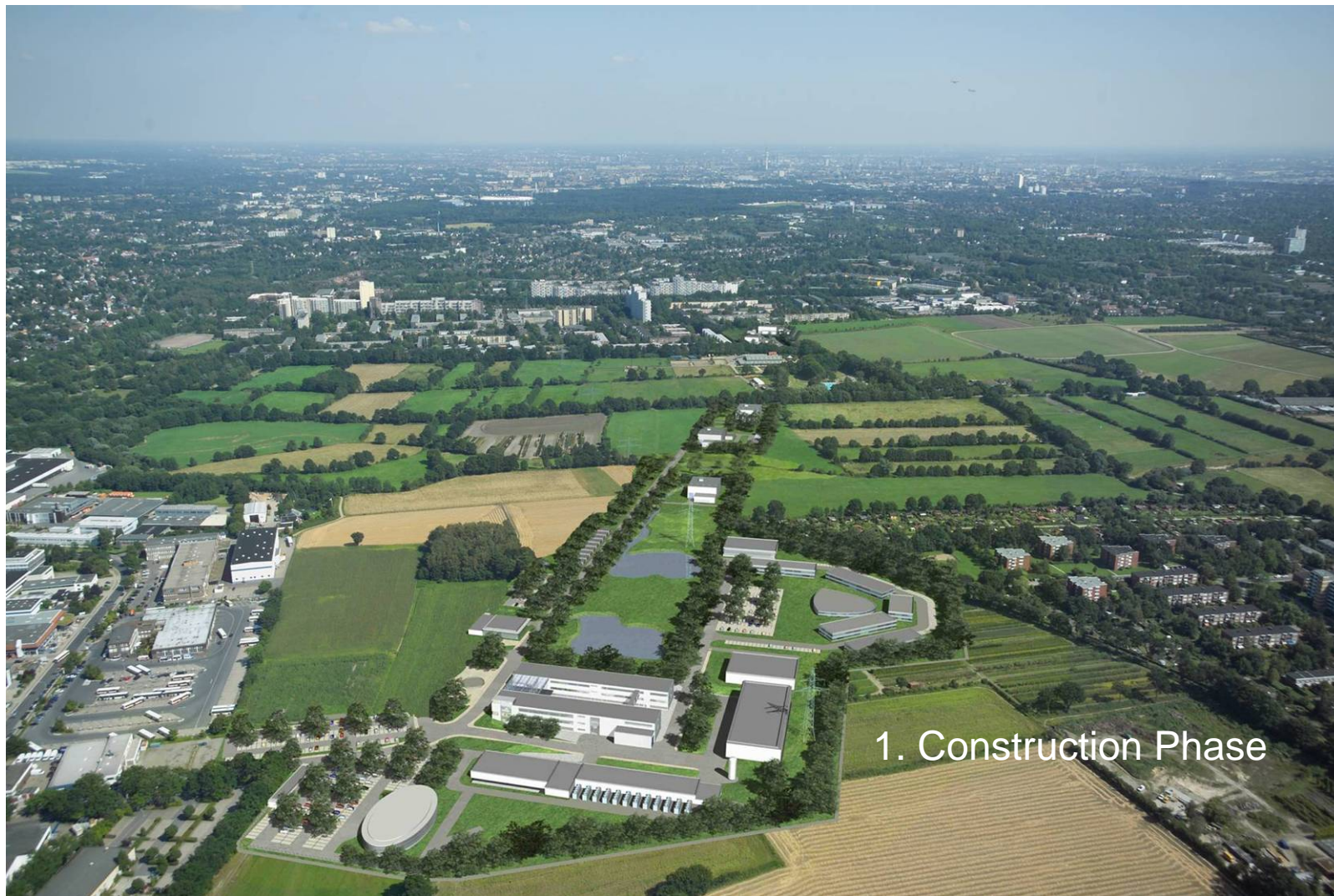
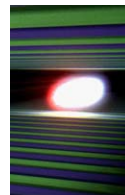
Power, Water,  
Cooling Supplies

Experimental Hall

Office Building

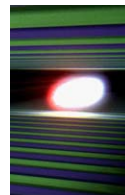


# Schenefeld Site – Computer Simulation

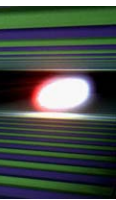




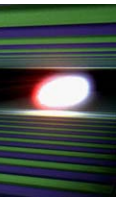
# Schenefeld Site – Experiment Complex



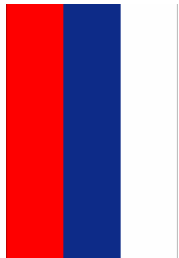
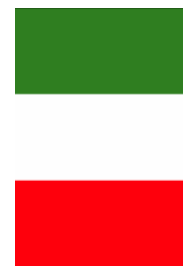
# Schenefeld Site



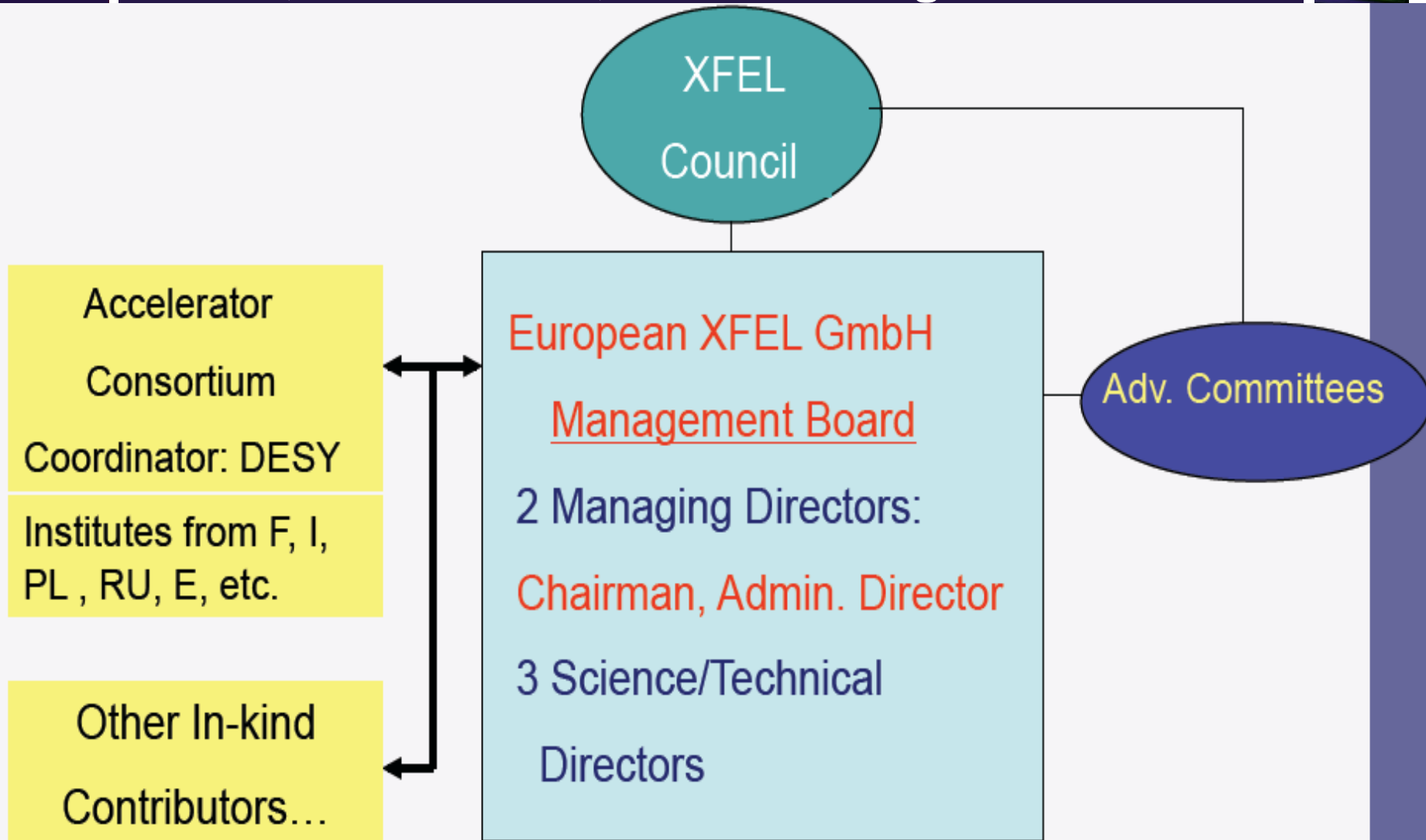
# The European XFEL Limited Liability Company



**Preparations are underway for the foundation of a company with research institutes of the different countries as shareholders, the European XFEL GmbH. Construction and operation of the XFEL are entrusted to this company**



# XFEL, Committees, Collaborating Institutes





# Management Board

Managing Directors (= "Geschäftsführer" in the sense of the GmbHG)

**Chairperson of the Management Board: M. Altarelli**

**Administrative Director**  
*K. Witte*

**Scientific Director**  
*S. Molodtsov*

**Scientific Director**  
*A. Schwarz*

**Scientific Director**  
*T. Tschentscher*

Human Resources

WP-74  
Photon Diagnostics

Civil construction including

WP-73  
X-Ray Optics

Assistant, Secretariat

Finance and Accounting

WP-79  
XHEXP1, Sample Environment

WP-31  
Site & Civil Construction  
WP-41/42/43  
Site Lot 1-3

WP-78  
Optical Lasers

Safety, Radioprotection

Procurement and Contracts, Customs

WP-85  
Scient. Instrument SQS

WP-44  
Site Engineering

WP-81  
Scient. Instrument FDE

Communication, PR

Law Office

WP-86  
Scient. Instrument SCS

WP-45  
AMTF Hall

WP-82  
Scient. Instrument HED

Internal Audit

Central Services incl. Library, User Administration, Travel Office

Technical Support Services, Mechanics, Electronics Workshops

Accelerator Liaison and WP-71 Undulators

WP-83  
Scient. Instrument MID

WP-75  
Detectors

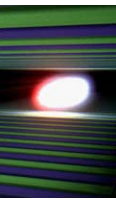
WP-84  
Scient. Instrument SPB

WP-76  
DAQ & Controls

IT, Computing Services



# Needed to Start the European XFEL GmbH



## 1. Convention between Governments

*with 6 Annexes, among which Annex 2, the **Articles of Association** (statutes, regulating how company works...)*

## 2. Final Act – agreement to apply the Convention before it is ratified by Parliaments, Ministries, etc.

**Also other documents, such as:**

- *Contracts between European XFEL and DESY (Host, Coordinator of Accel. Consortium, service provider...)*
- *In-kind contribution rules and template contracts*

## What is happening now?

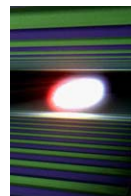
**Before Convention can be signed, text must be translated into:**

*Chinese, French, German, Italian, Russian, Spanish and...all 7 texts must be declared equivalent by a “Translators’ Conference”!*

....After that a “Signature Ceremony” can be scheduled

■ ***As of today:...***

- - Official Chinese and Russian translations not yet delivered
- - Final authorization from Russian cabinet pending



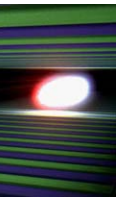
There are at present 32 people working in the AER 19 building, most of them with DESY contracts.

Recruitment very advanced for 9 scientific, engineering and administrative positions.

More down the line







## ■ Status of Recruitment of Leading Scientists (Instruments 1 to 6)

Candidates selected (after shortlisting and interviews) for three instruments:

- Femtosecond Diffraction Experiments (Christian Bressler)
- Small Quantum Systems
- High Energy-Density

accepted (in principle) specific and detailed offers, negotiations concluded

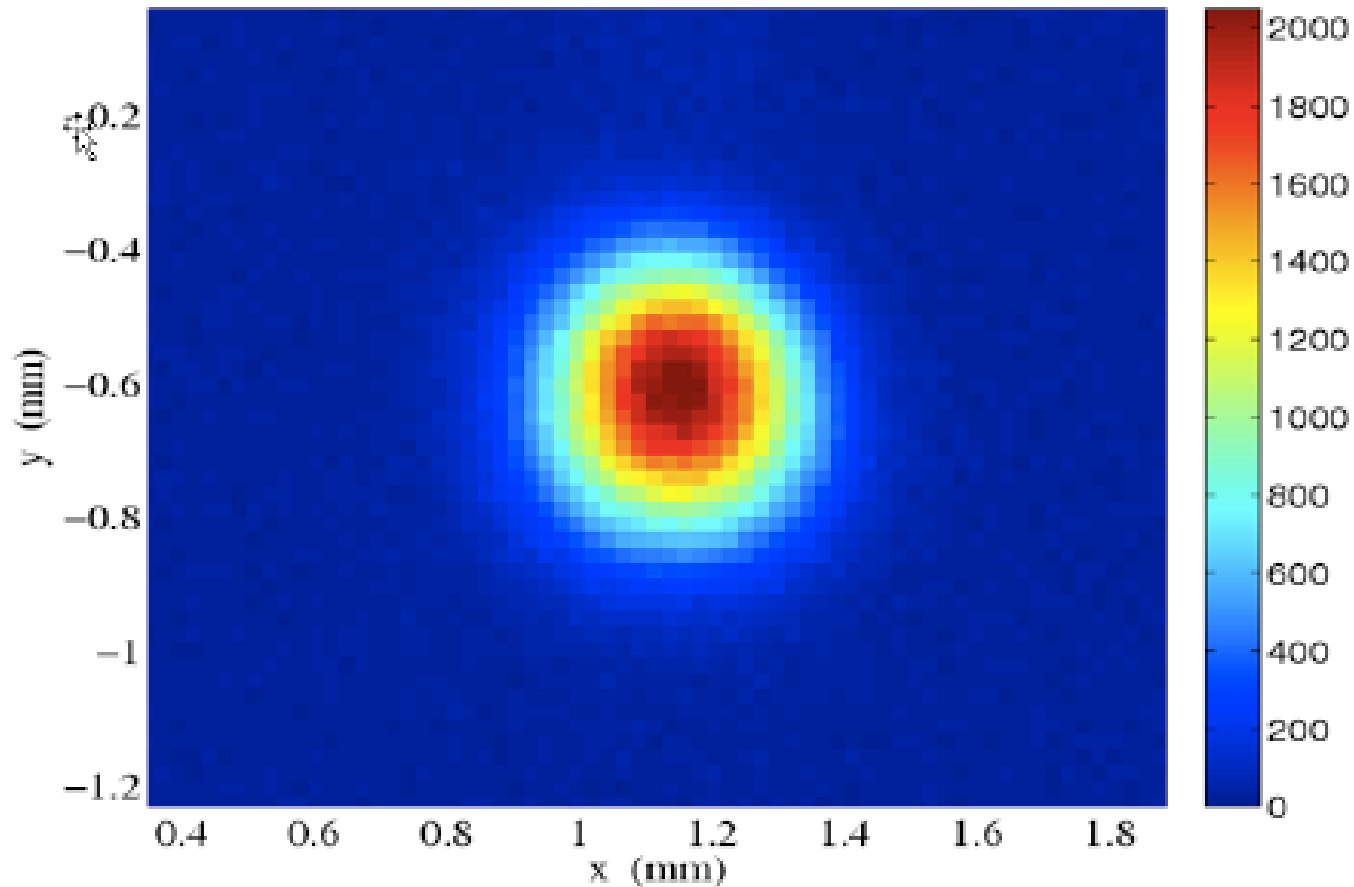
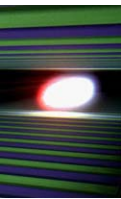
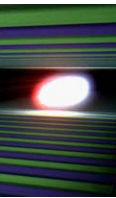


Figure 10: FEL x-rays at  $1.5 \text{ \AA}$  on a YAG screen 50 m after the last inserted undulator (see Table 1 for measured parameters).

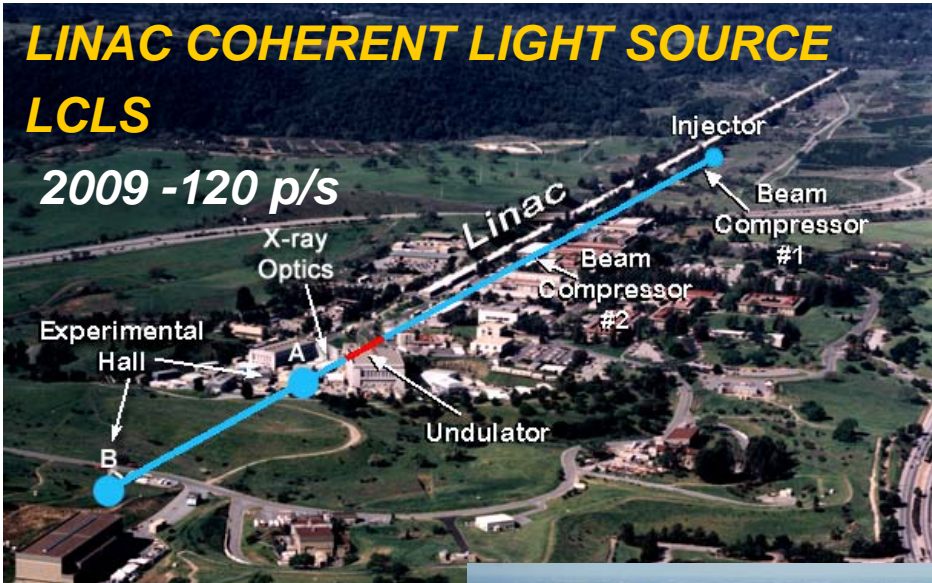
# Hard x-ray FEL Projects



## LINAC COHERENT LIGHT SOURCE

### LCLS

2009 - 120 p/s



2011-3000 p/s

**SCSS**  
**S**pring-8 **C**ompact **S**ASE **S**ource

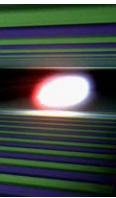
## European XFEL Facility •

2014 - 30 000 p/s

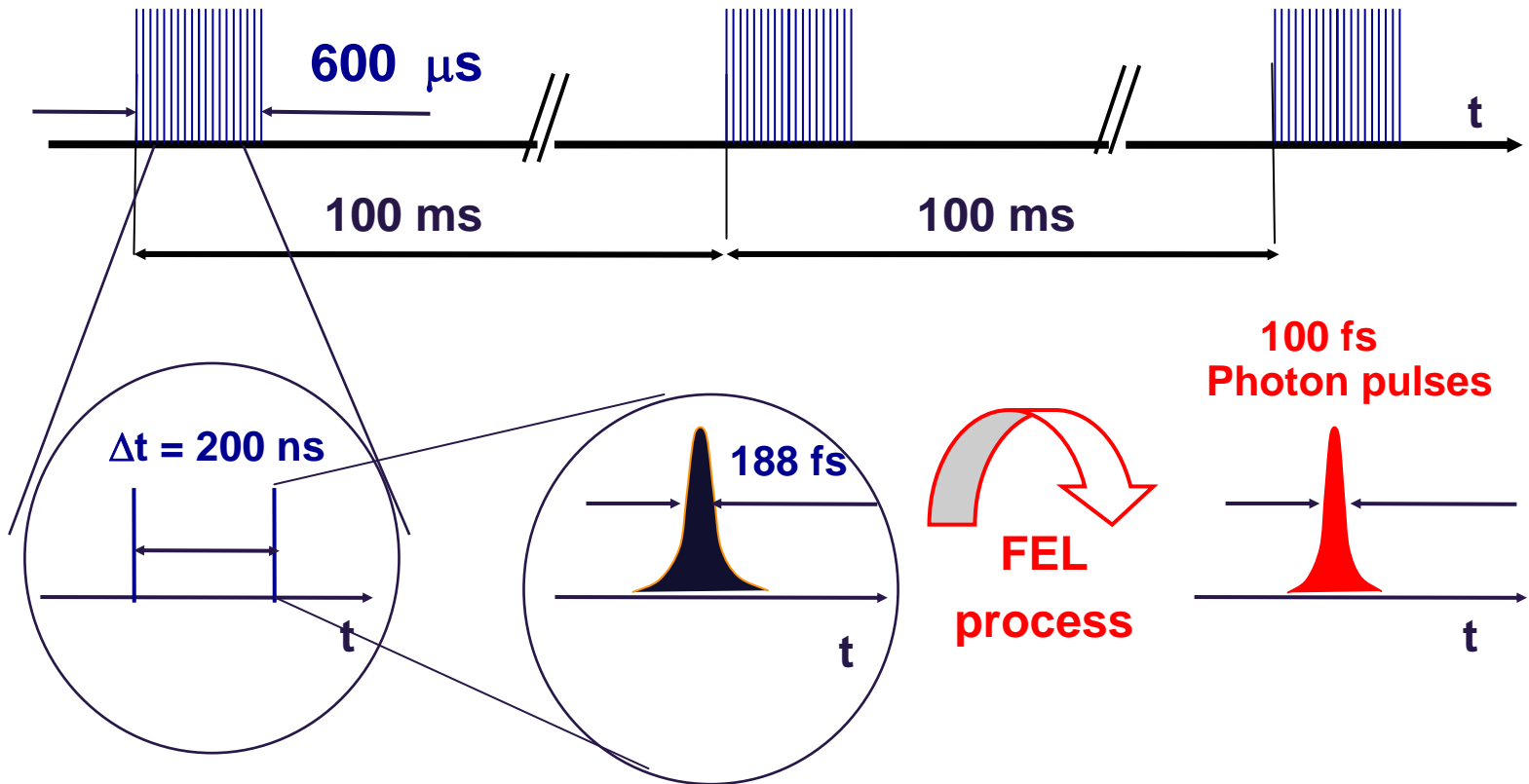




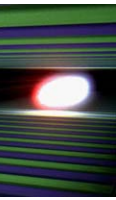
# European XFEL Project - Time Structure



## Electron bunch trains (with up to 3000 bunches à 1 nC)



# Exploitation of repetition rate



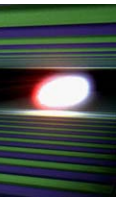
## ■ Detectors allowing acquisition of images at 5 MHz

→ *3 Development projects under way for acquisition of up to 512 successive 1 M Pixel images at 5 MHz* → [talk by Heinz Graafsma]

## ■ Lasers allowing Pump and Probe at 5 MHz

→ *Plan launch of a development initiative in partnership with other institutes*

# Facing the competition

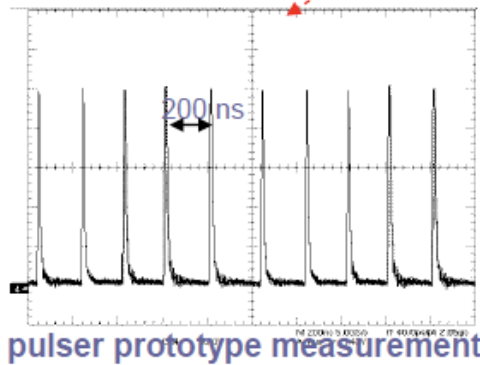
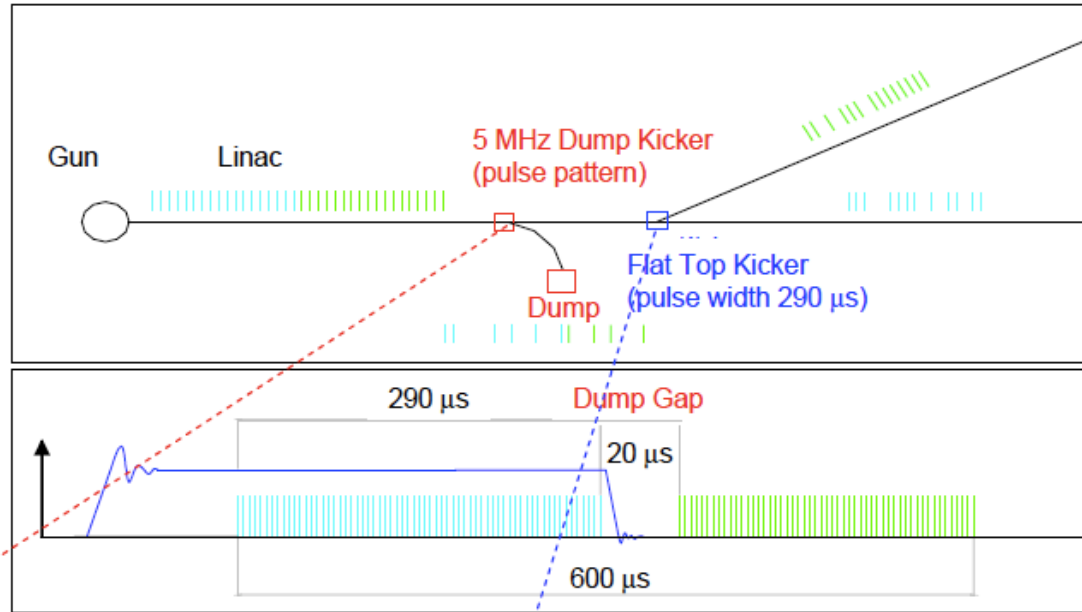
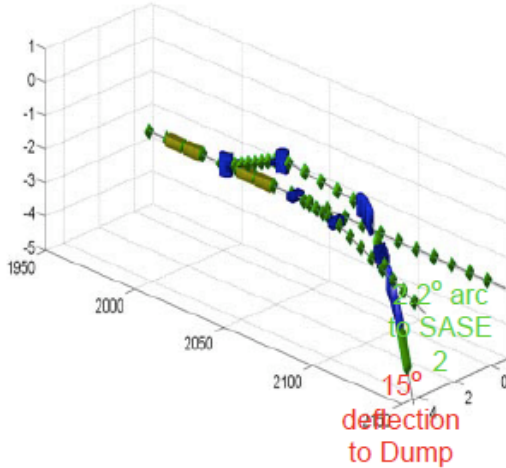


- Ensure exploitation of repetition rate at best
- Provide “simultaneous” beam time to different users’ groups
- Ensure high reliability and stability, top level experimental facilities

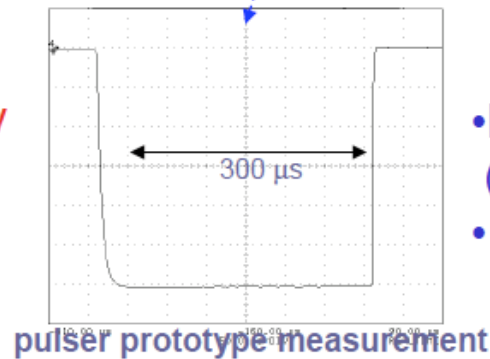


# Splitting a bunch train between 2 beamlines

Thanks to W. Decking



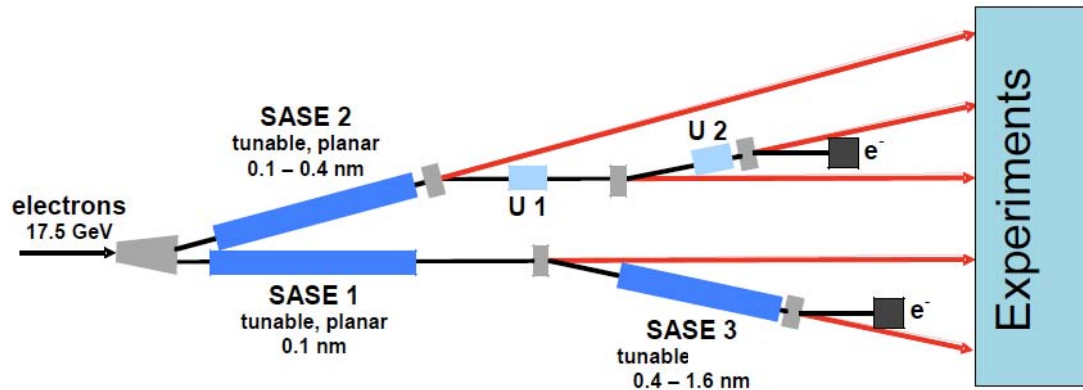
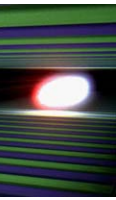
- low accuracy (>1 %)
- 5 MHz burst operation



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

Winni Decking

# Ideal operating conditions

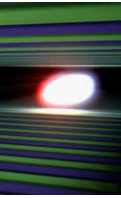


3 Experiments, 1 each on SASE1+SASE3 and 1 on SASE2

- can receive up to ~1,400 bunches 10 times/s
- can accumulate up to ~ 500 images 10 times /s

(and later 5!)

# Acknowledgments



■ We thank for financial support so far

*BMBF and DESY*



Bundesministerium  
für Bildung  
und Forschung



*The European Commission*



*The Slovakian, Swedish,  
Spanish and UK contracting  
parties*



...And the countries already supporting In-kind work in their labs