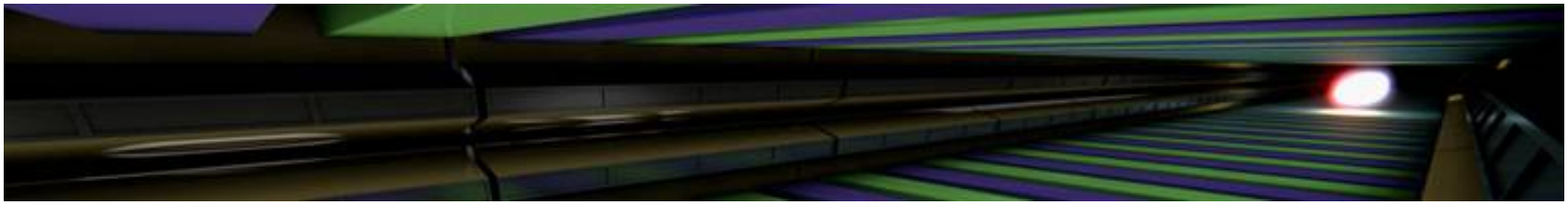
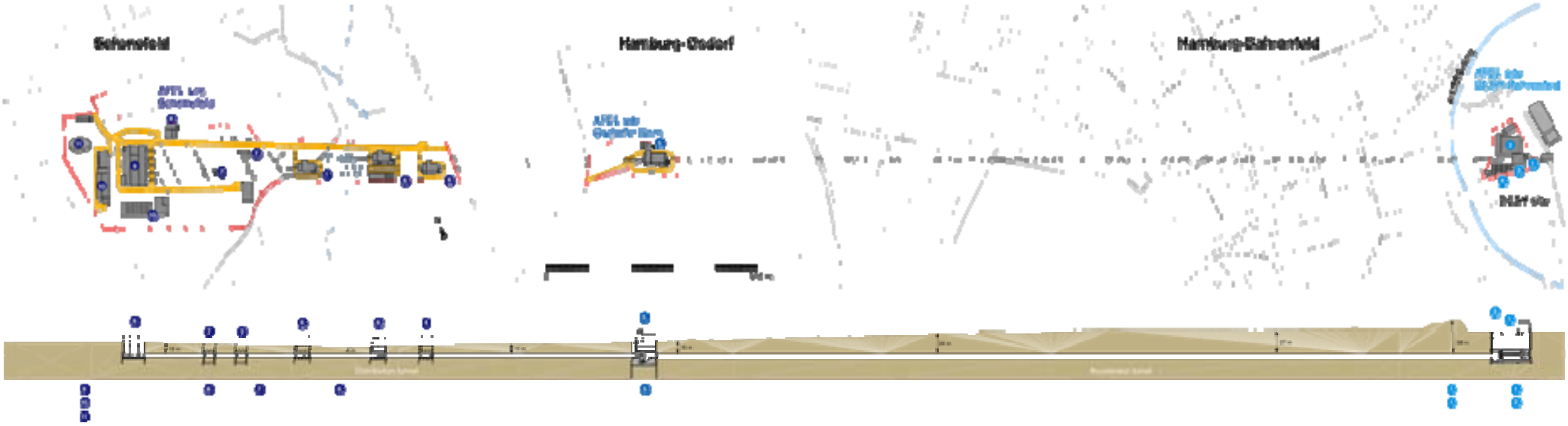


European XFEL

Status of Technical Developments

Massimo Altarelli

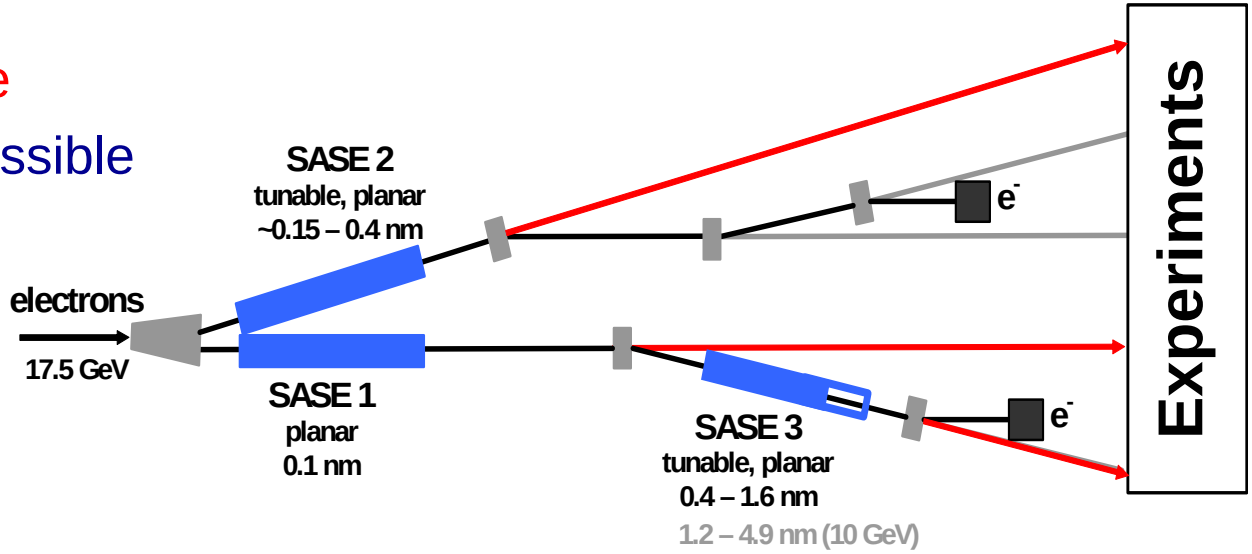
On behalf also of Serguei Molodtsov, Andreas Schwarz, Thomas Tschentscher and Karl Witte



The European XFEL – "Start-up" Version

Some specifications

- Photon energy 0.8–12.4 keV
- Pulse duration <100 fs
- Pulse energy few mJ
- super-conducting accelerator
- 10 Hz/4.5 MHz (27 000 b/s)
- 3 beamlines/6 instruments
  - extension to TDR
    version with 5 BLs
    and 10 instruments possible
- Various other extensions possible
  - variable polarization ID's
  - shorter wavelengths
  - possibly CW operation

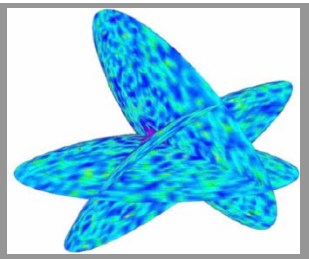


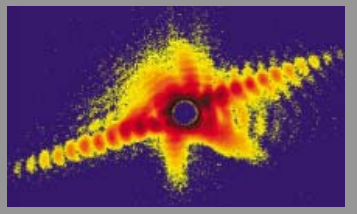
- First beam 2014
- Start of user operation 2015

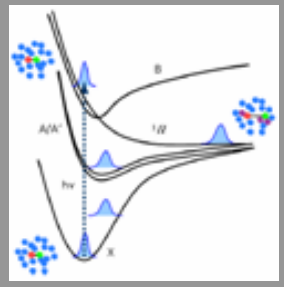
Scientific instruments

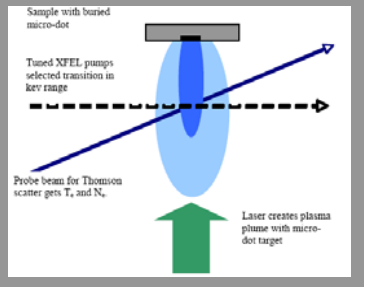
Hard x-rays

- Ultrafast Coherent Diffraction Imaging of Single Particles, Clusters, and Biomolecules (SPB)
  - Structure determination of single particles: atomic clusters, bio-molecules, virus particles, cells.
- Materials Imaging & Dynamics (MID)
  - Structure determination of nano- devices and dynamics at the nanoscale.
- Femtosecond Diffraction Experiments (FDE)
  - Time-resolved investigations of the dynamics of solids, liquids, gases
- High Energy Density Matter (HED)
  - Investigation of matter under extreme conditions using hard x-ray FEL radiation, e.g. probing dense plasmas



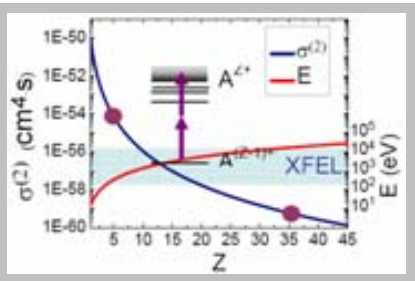


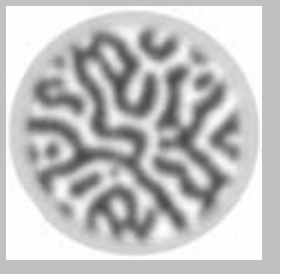




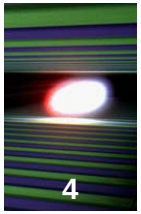
Soft x-rays

- Small Quantum Systems (SQS)
  - Investigation of atoms, ions, molecules and clusters in intense fields and non-linear phenomena
- Soft x-ray Coherent Scattering (SCS)
  - Structure and dynamics of nano-systems and of non-reproducible biological objects



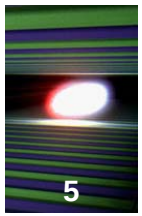


Much technical work already in progress



DESY's role as host laboratory for the Project Team, early financial support by Germany (and to a lesser extent also by EU and by other countries) allowed substantial work and developments to start earlier than formal signature and creation of the European XFEL GmbH non-profit Company in fall 2009

Organization of the European XFEL



European XFEL GmbH

Council (Shareholders)

Chair: H. Dosch

Management Board

Managing Directors

M.Altarelli, Chair

K. Witte, Admin. Director

Science Directors

S. Molodtsov

A. Schwarz

T. Tschentscher

Accelerator Consortium

Coordinator:

R. Brinkmann, DESY

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

Other In-kind Contributors

Advisory Committees

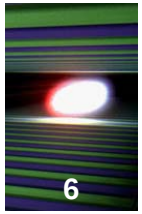
SAC

MAC

AFC

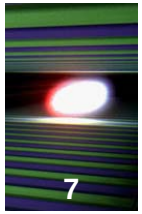
IKRC

XFEL Workpackages



WPG1 Linac	WPG1 Linac	WPG2 Accelerator Subsystems	WPG4 Control & Operation	WPG5 Infrastructure	WPG3 Photon Beam System	WPG3 Photon Beam System	WPG6 Sites & Buildings
WP01 RF System *Stefan Choroba*	**WP07** Freq. Tuners *L. Lilje / A. Bosotti*	**WP12** Warm magnets *Bernward Krause*	**WP28** Acc Control Sys. *Kay Rehlich*	**WP10** AMTF *Bernd Petersen*	**WP71** Undulators *Joachim Pflüger*	**WP73** X-Ray Optics & Tr *Harald Sinn*	**WP31** Sites & Civil Cons *H-J Christ*
WP02 Low Level RF *Stefan Simrock*	**WP08** Cold vacuum *Lutz Lilje*	**WP14** Injector *Klaus Flöttmann*	**WP29** Operab. & Reliab *NN*	**WP13** Cryogenics *Bernd Petersen*	**WP74** X-Ray diagnostics *Jan Grünert*	**WP78** Optical lasers *NN*	**WP41** Site Lot 1 *H-J Christ*
WP03 Acc. Modules *O. Napoli / K. Jensch*	**WP09** Cav. String Assy. *B. Visentin A. Matheisen*	**WP15** Bunch compress. *Torsten Limberg*	**WP35** Radiation Safety *Norbert Tesch*	**WP32** Survey & Align. *Johannes Prenting*	**WP75** Detector Dev. *Heinz Graafsma*	**WP81** FDE Instr. *Christian Bressler*	**WP42** Site Lot 2 *H-J Christ*
WP04 SC Cavities *W. Singer P. Michelato*	**WP11** Cold Magnets *HD Brück / F. Toral*	**WP16** Lattice *Winfried Decking*	**WP36** General Safety *Stefan Schrader*	**WP33** Tunnel Installation *Norbert Meyners*	**WP76** DAQ & Control *Chris.Youngmann*	**WP82** HED Instr. *NN*	**WP43** Site Lot 3 *H-J Christ*
WP05 Power Couplers *A. Falou / WD Möller*	**WP46** 3.9 GHz System *E. Vogel / P. Pierini*	**WP17** Stand. e-b diagn. *Dirk Nölle*	**WP38** Pers. Interlock *Brunhilde Racky*	**WP34** Utilities *J-P. Jensen*	**WP79** Sample Environ. *NN*	**WP83** MID Instr. *NN*	**WP44** Site Engineering *H-J Christ*
WP06 HOM Couplers *J. Sekutowicz / E. Plawski*		**WP18** Spec. e-b diagn. *Holger Schlarb*	**WP39** EMC *Herbert Kapitza*	**WP40** Info & Proc. Supp *Lars Hagge*	**WP85** SQS Instr. *NN*	**WP84** SPB Instr. *NN*	**WP45** AMTF Hall *H-J Christ*
		WP19 Warm vacuum *Lutz Lilje*			**WP86** SCS Instr. *NN*		
		WP20 Beam Dumps *Michael Schmitz*					
		WP21 FEL Concepts *Mikhail Yurkov*					

Contributions of countries (other than Germany)



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		WP19 Warm vacuum *Lutz Lilje*			WP86 SCS Instr. *NN*		
		WP20 Beam Dumps *Michael Schmitz*					
		WP21 FEL Concepts *Mikhail Yurkov*					

RU

ES

SE

CH

FR

IT

PL

List of in-kind contributions *(accepted)*

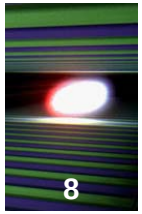
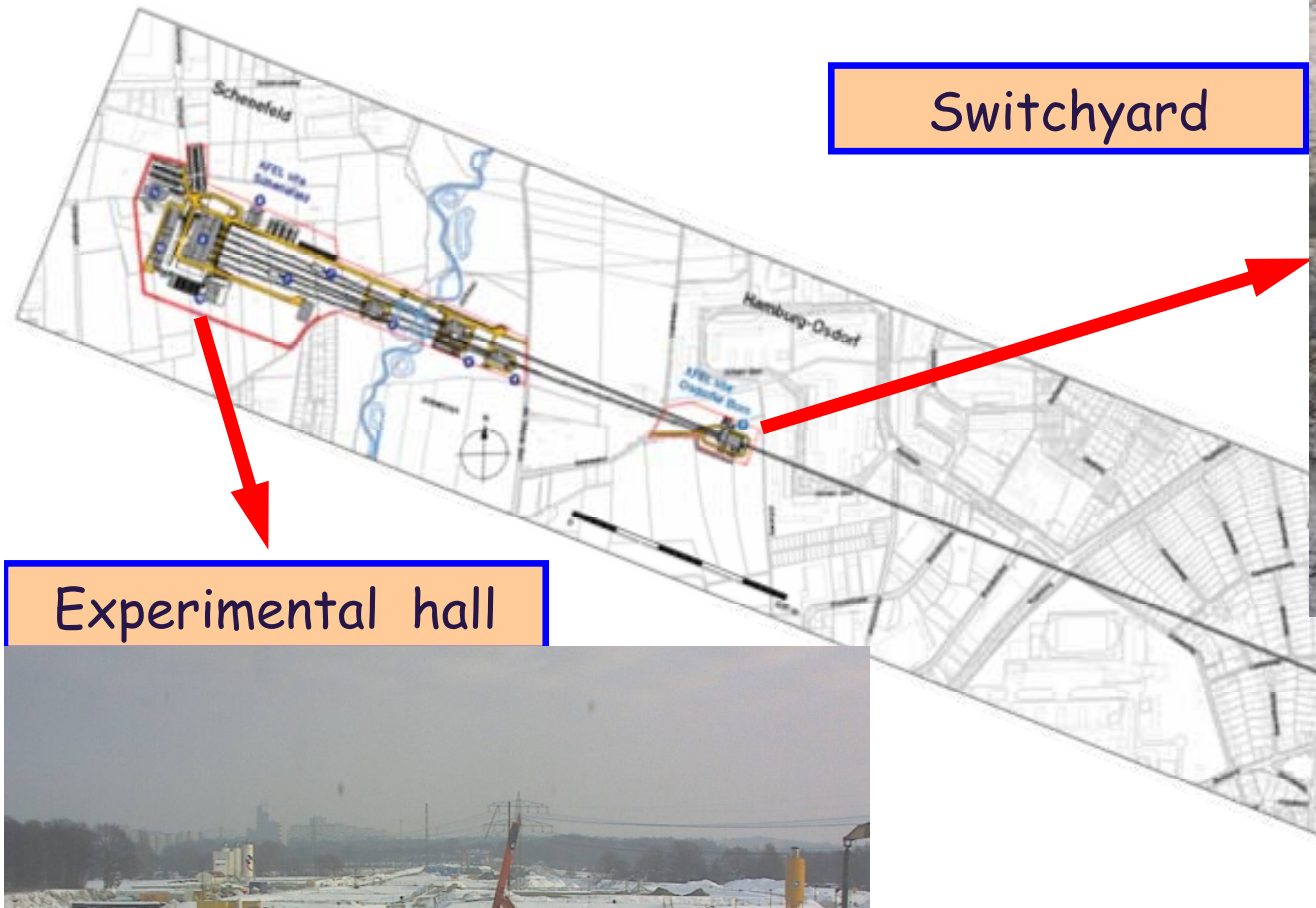


Table of accepted contributions by country

Abr	Country	Institute	Description IKC
FR	France	CNRS (LAL)	800 Power couplers
		CEA (IRFU)	101 cavity strings assembly
		CEA (IRFU)	101 cryomodules assembly
		CEA (+ PSI + DESY)	BPMs system
IT	Italy	INFN	Nb cavities (50%)
		INFN	Cold masses for cryomodules (25%)
		INFN	3.9 GHz accelerator cryomodule
PL	Poland	IJP Swierk	HOM couplers
		IFJ-PAN Cracow	Cold vacuum
		IFJ-PAN Cracow	Warm vacuum
		Wroclav Univ. Of Technology	Cryogenics for AMTF
		IFJ-PAN Cracow	RF for AMTF
		IFJ-PAN Cracow	AMTF operation
			Cold magnets
RU	Russia	IHEP Protvino	AMTF Cryogenics system
			Cryogenics
			Beam dump
			Beam diagnostics
		NIIEFA St Petersburg (Efremov Institute)	77 dipoles
			397 quadrupoles
			39 sextupoles
			256 correction magnets
		BINP Novosibirsk (Budker Institute)	Connector cables for pulse transformers
			127 quadrupole magnets
			Cold vacuum
			Warm vacuum
			3 test benches for cryomodules at AMTF
		INR Moscow (+DESY)	3 Transverse Deflecting Structures
ES	Spain	CELLS	21 undulators for SASE3
		CIEMAT	Cold magnets
		CIEMAT (+DESY)	222 power supplies (4 types) for cold magnets
		CIEMAT	Undulators intersections: 91 phase shifters, quadrupole movers, granite bases + 1 prototype
SE	Sweden	KTH Stockholm BIOX	Heat load investigations on diffractive optics
		Uppsala University	Laser heater system for injector
		Manne Siegbahn Lab	Fiducial marking of undulator quadrupoles
		Stockholm University (PhySto)	Timing & synchr. System + configuration management
		Manne Siegbahn Lab	Temperature Measurement System for undulators
CH	Switzerland	PSI (+CEA, DESY)	BPMs
		PSI (+DESY)	Intra-Bunchtrain Feedback System IBFB

Civil construction started in Jan. 2009



Switchyard

Experimental hall

Injector (DESY)

European XFEL

DESY Bahrenfeld Site – Injector Complex

Injector complex

lengths: 95 m

depths: 38 m und 32 m

ground area: ~ 1500 m²

modulator hall

ground area: 46 m x 41 m

main entrance building

height: 13 m

injector entrance hall

height: 11m

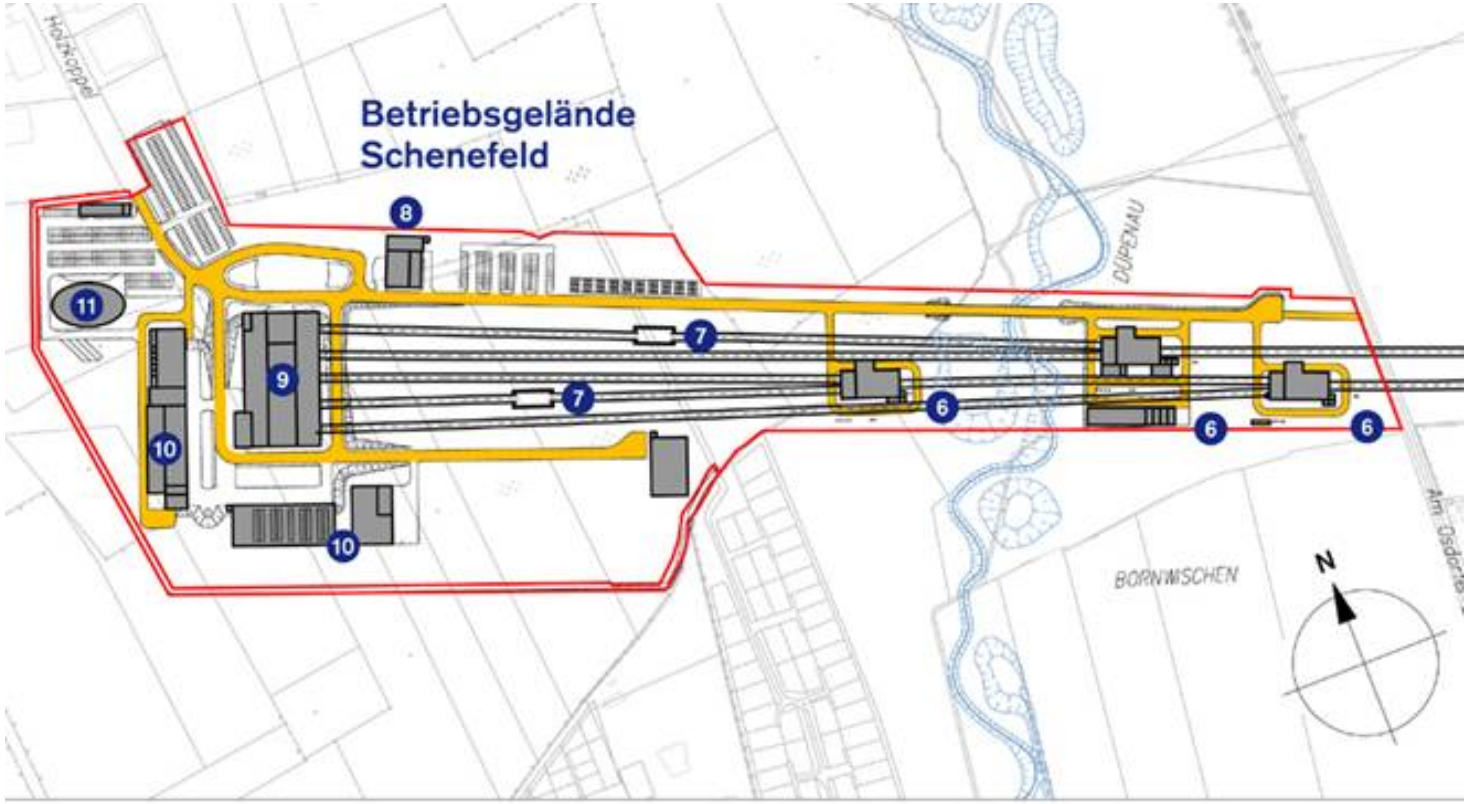
linac tunnel

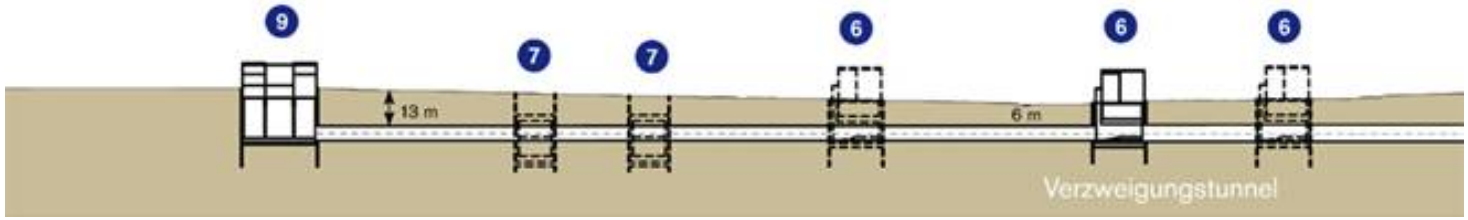
soil above tunnel: ~ 35 m

DESY-Bahrenfeld site, end of Sept.

DESY Bahrenfeld site

Schenefeld Site





- Distribution Shafts
- Power, Water, Cooling Supplies
- Experimental Hall
- Office Building

Schenefeld Site – Experiment Complex

Schenefeld Site – Computer Simulation

Aerial View

Schenefeld site, Jan. 2010

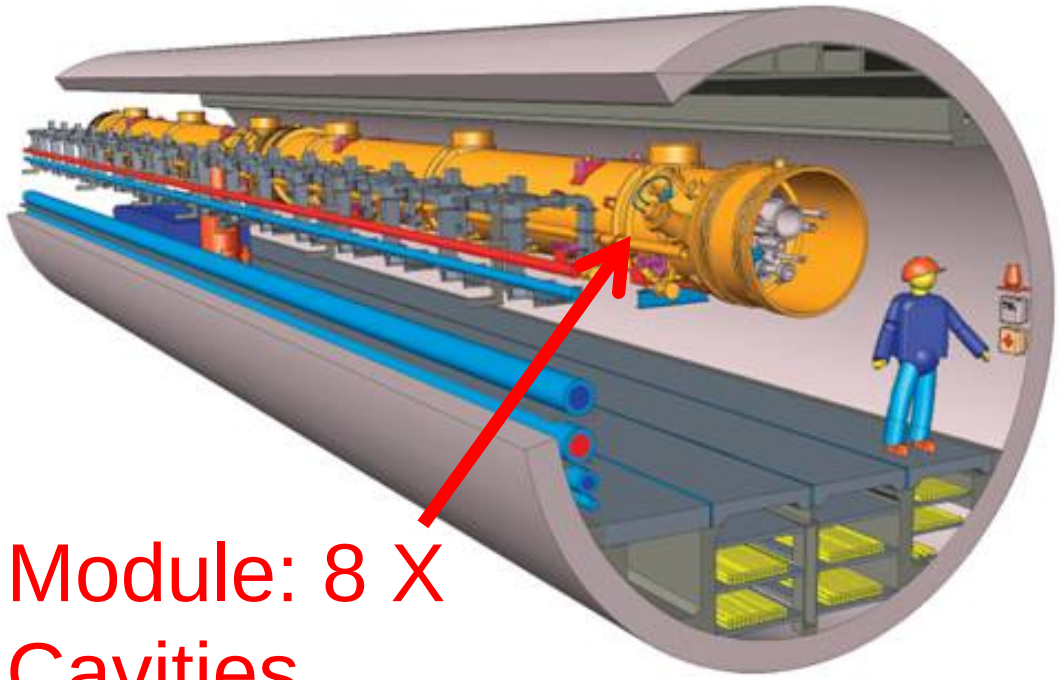
Accelerator Module Test Facility AMTF

Nov. 2009

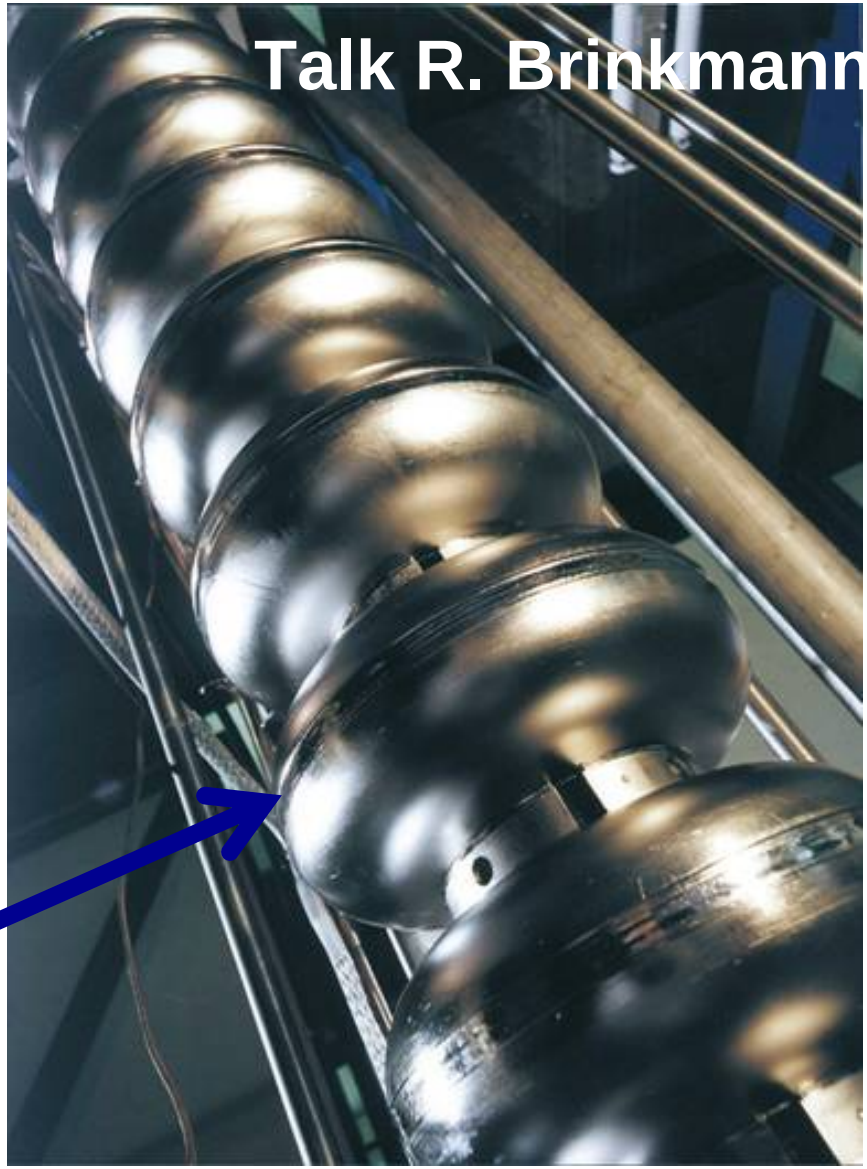
Accelerator Module Prototype PXFEL1

Superconducting "TESLA" Technology

100 8-Cavity modules, 1.4 km, 17.5 GeV Electron Energy

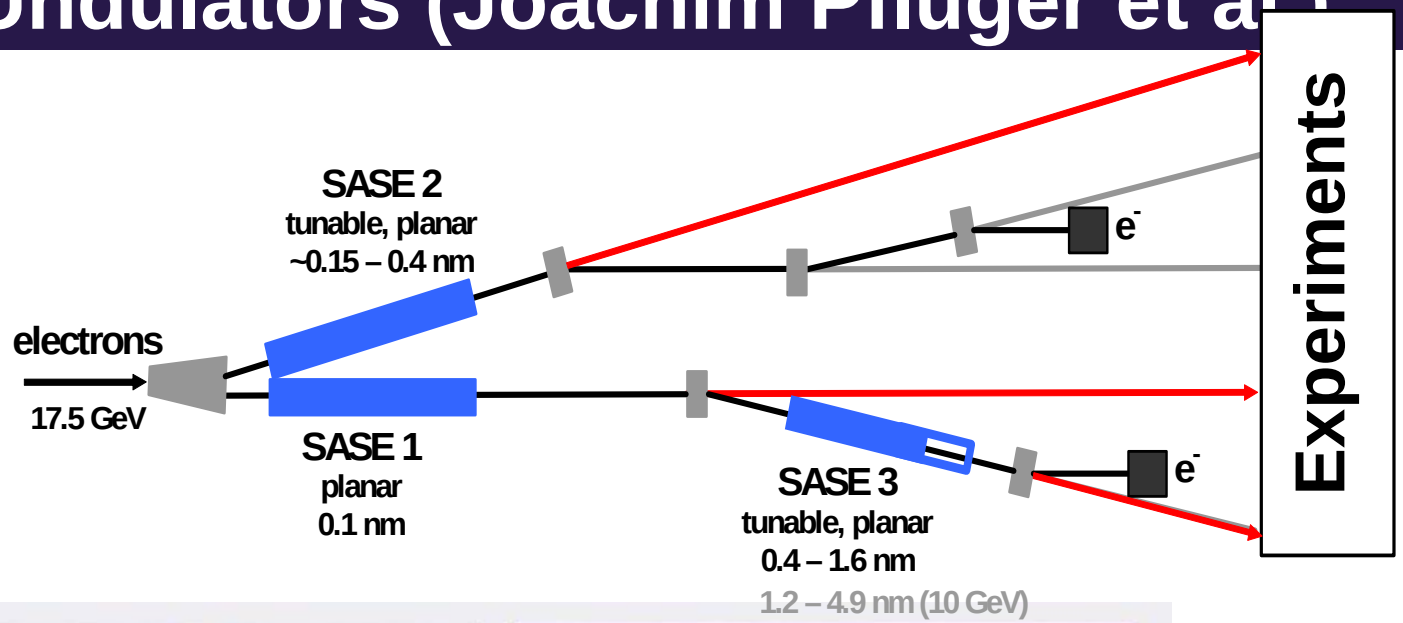


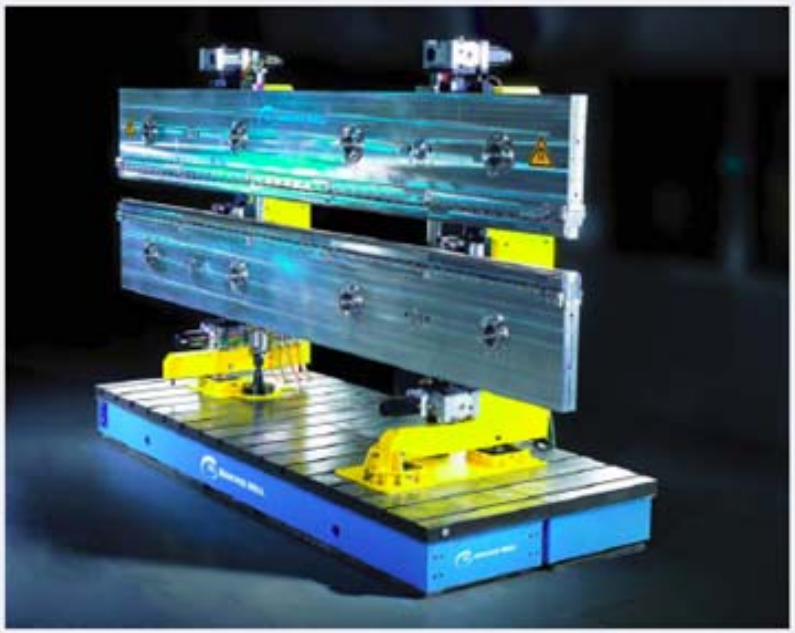
Module: 8 X Cavities



Niobium Cavities

Undulators (Joachim Pflüger et al.)



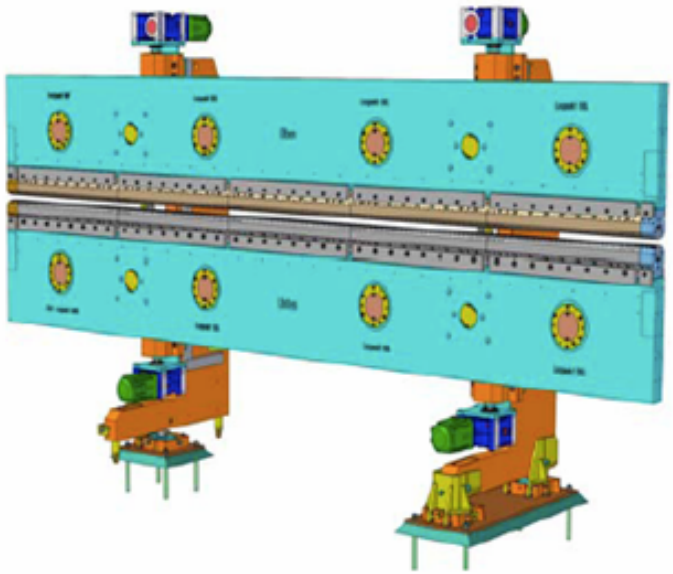


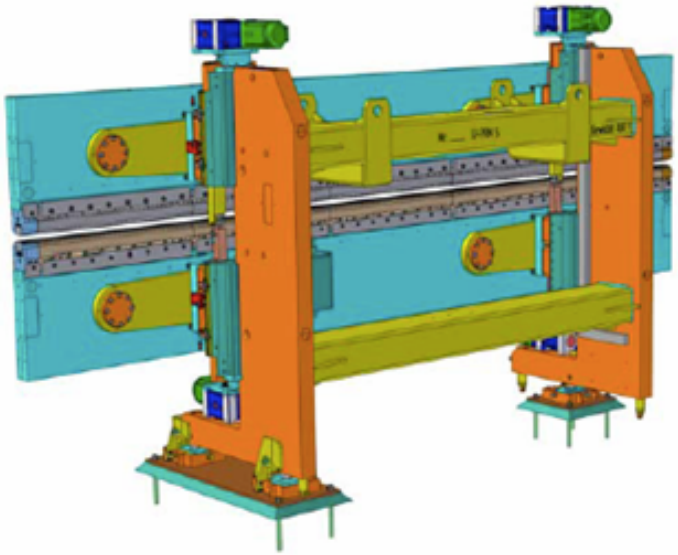
5 m

2 m

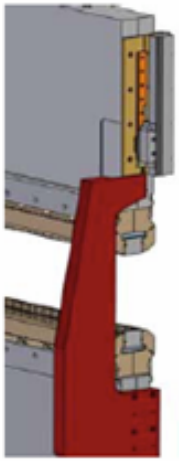
Prototypes developed jointly with Petra III

Undulators (Joachim Pflüger et al.)





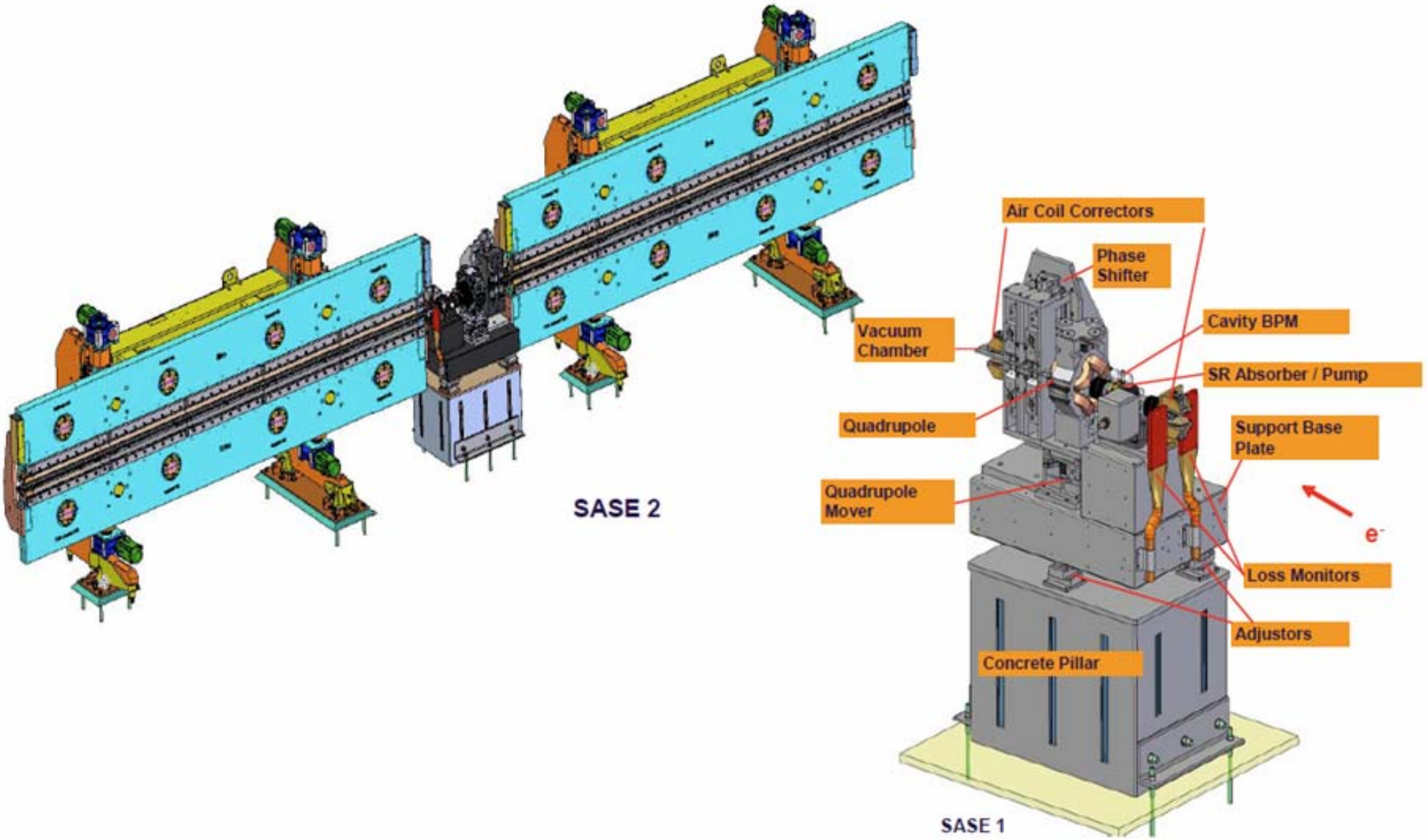
Gap Measurement
Accuracy ±1µm



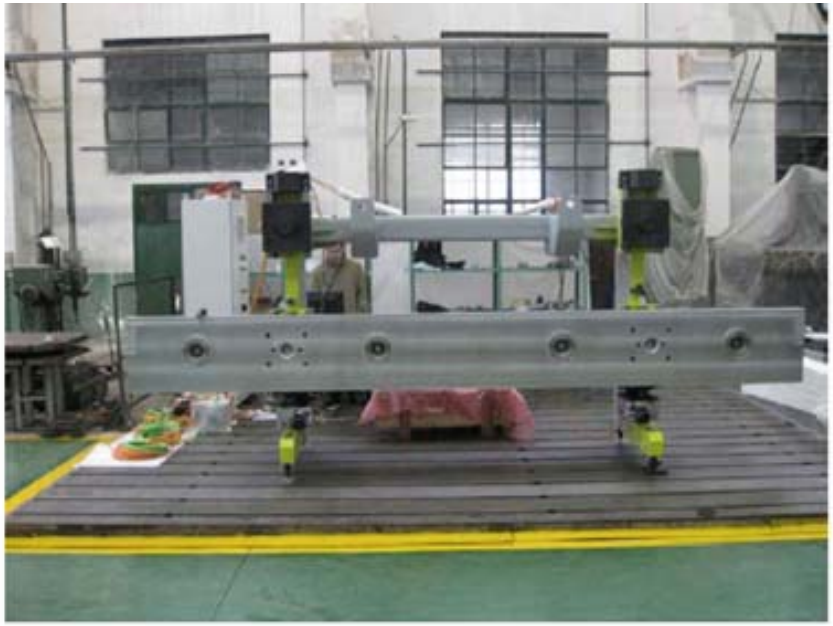
Special Attention:

1. Shear deformation and compressive deformation
2. Material pairing / Bimetallic bending
3. Four point support of girders
4. Four Motors, electronic gears
5. Forced girder guiding
6. Precision measurement of gap / Motor feedback to ±1µm, avoiding Abbé errors

Undulator Intersections (J. Pflüger et al.)



U48 / SASE2 Prototype IHEP Beijing



Support Mechanics at IPP workshop in Hefei

Assembly of a magnet module at IHEP

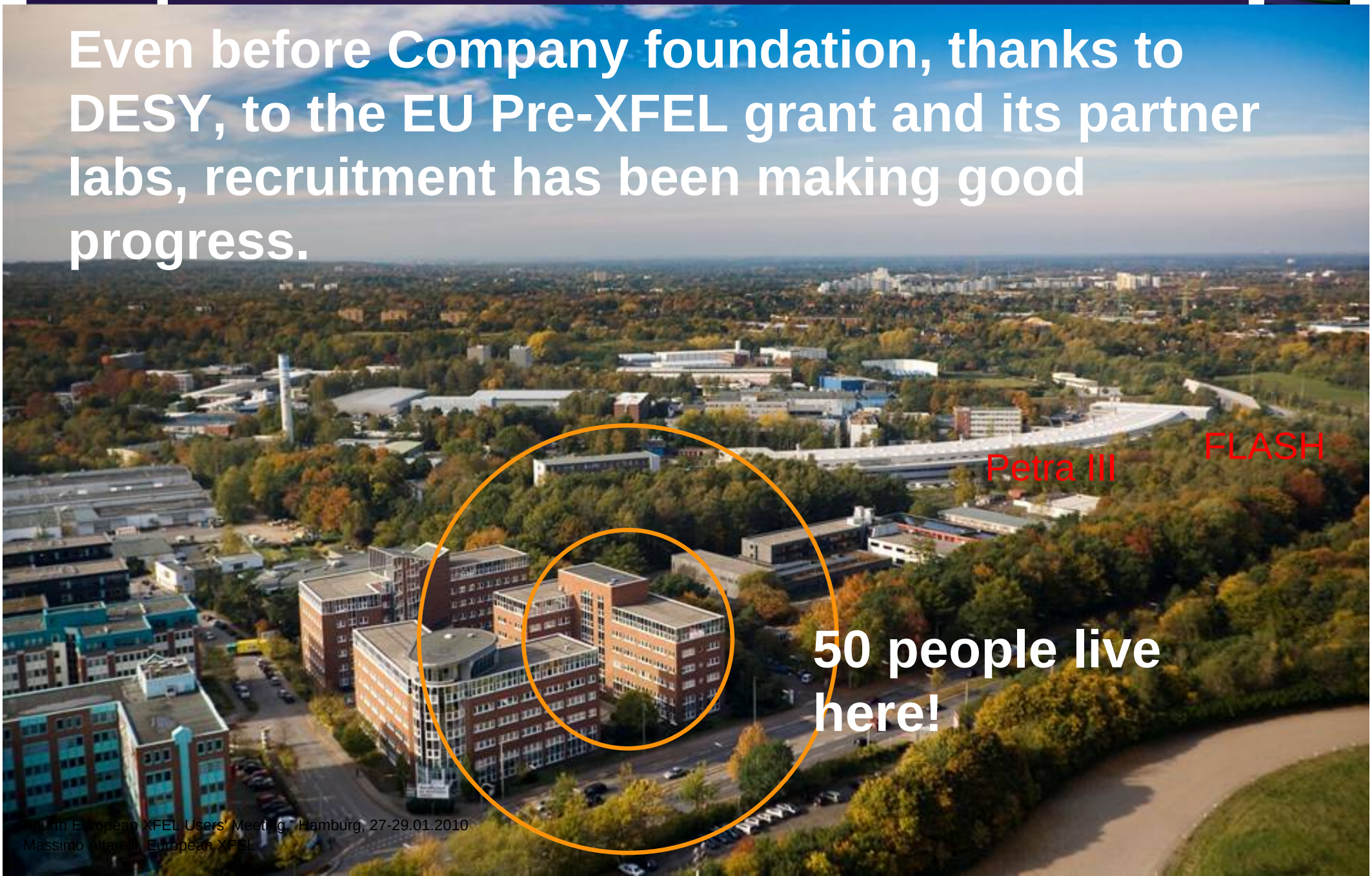
Using XFEL Design drawings, 100% Compliance with Specs, Support by XFEL

Status Dec 8, 2009

- All parts manufactured
- Great care with critical items (girder)
- ≈50% Assembled
- Beckhoff Control System works

Recruitment

Even before Company foundation, thanks to DESY, to the EU Pre-XFEL grant and its partner labs, recruitment has been making good progress.



April 10, 2009: the big news from LCLS!

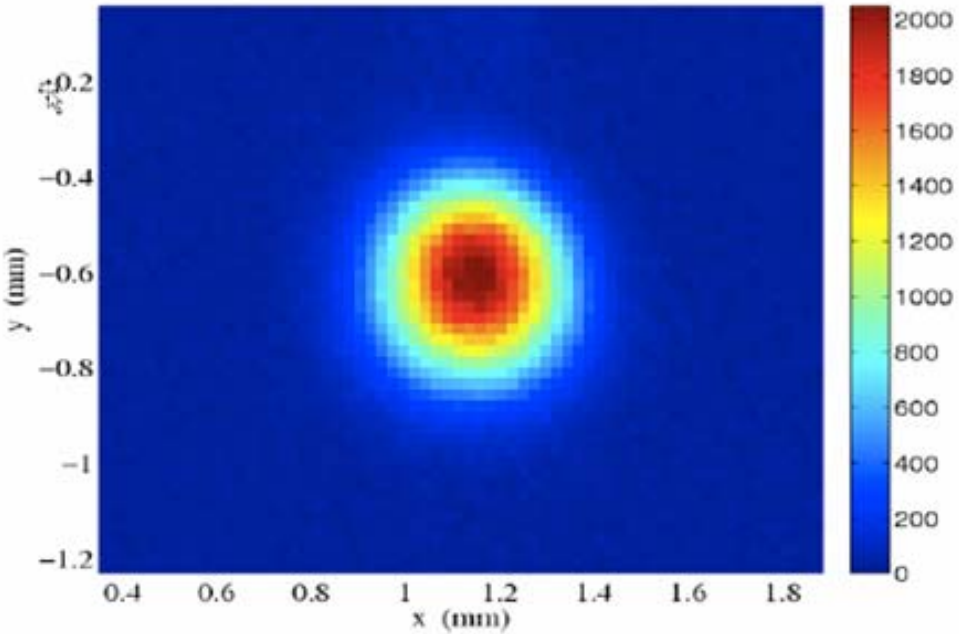
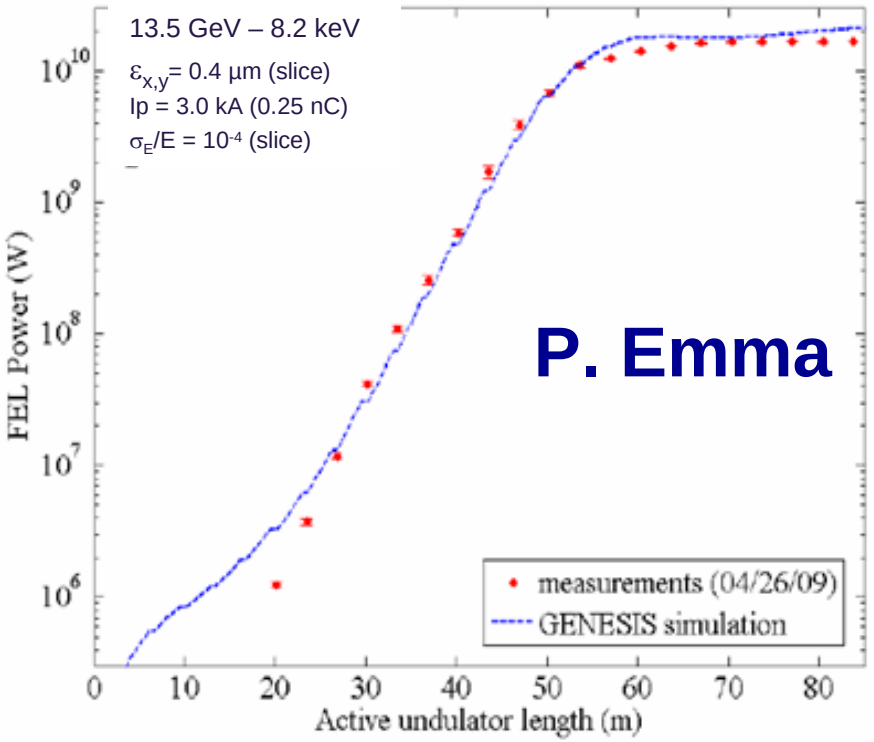


Figure 10: FEL x-rays at 1.5 Å on a YAG screen 50 m after the last inserted undulator (see Table 1 for measured parameters).

SASE process very robust at x-ray wavelengths.



New short-wavelength SASE record

First spatially coherent hard x-rays

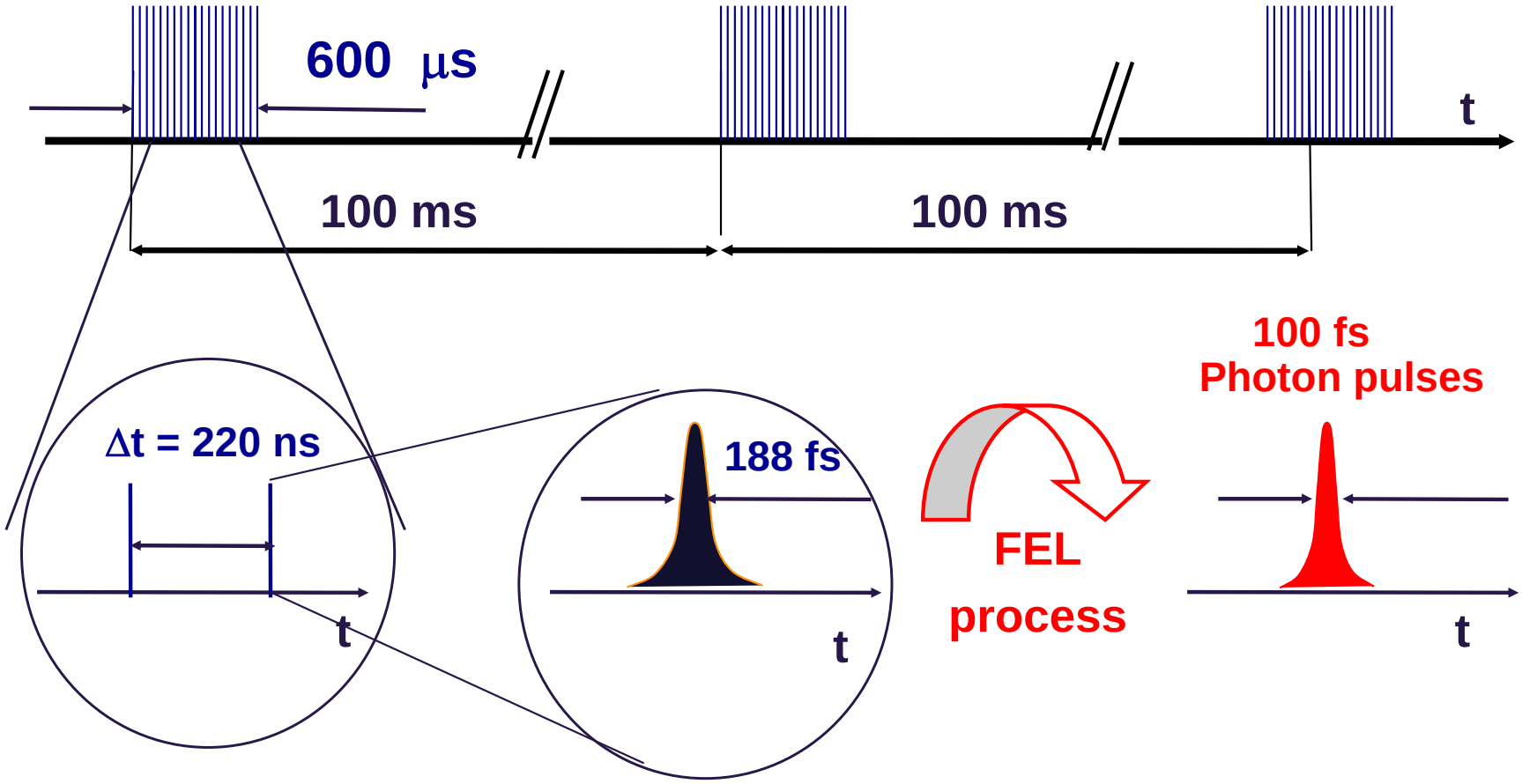
What do we learn from LCLS?

What is the European XFEL adding in 2014-2015?

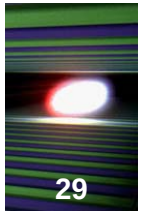
First European XFEL MAC and SAC meeting

European XFEL Project - Time Structure

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



Instrumentation developments



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

Exploitation of repetition rate

- Optical elements sustaining the heat load

→ *Develop diamond technology, suitable geometries* (H. Sinn)

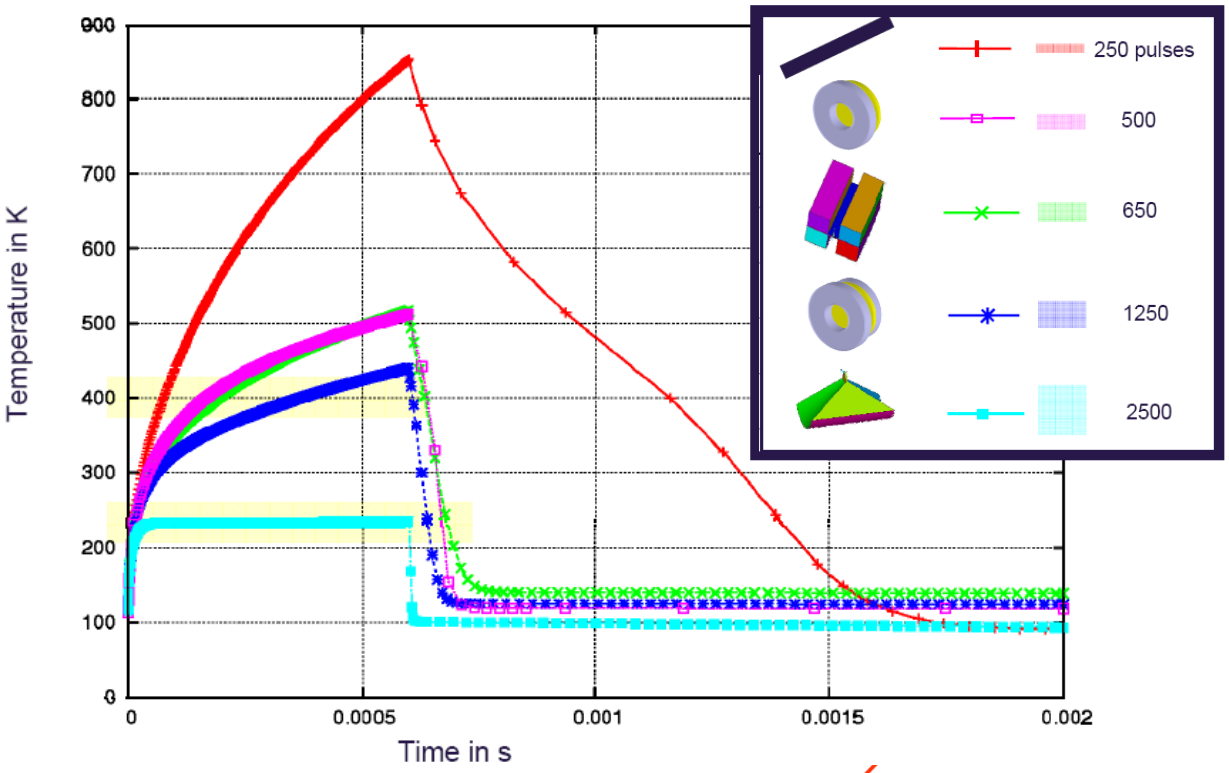
Detectors allowing acquisition of images at 4.5 MHz

→ *3 Development projects under way for acquisition of up to 512 successive M Pixel images at 4.5 MHz* (H. Graafsma)

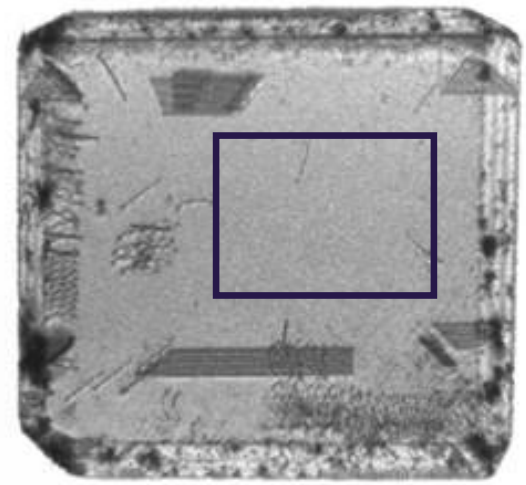
- Lasers allowing Pump and Probe at 4.5 MHz

→ *Plan launch of a development initiative in partnership with other institutes* (Th. Tschentscher, NN)

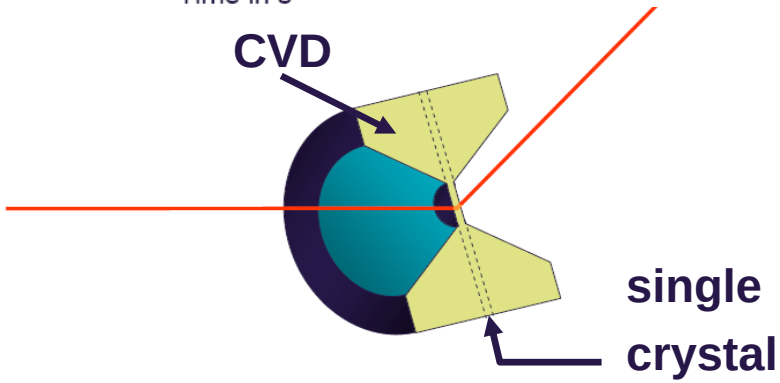
Monochromator crystals (H. Sinn et al.)



microscope



x-ray topogram



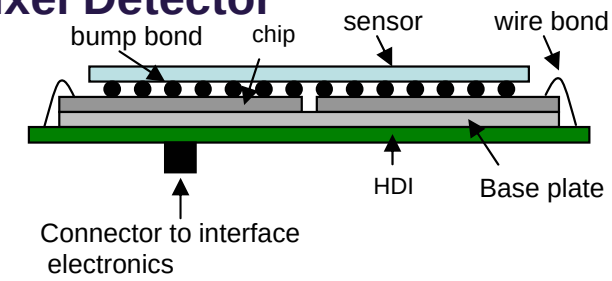
L. Samoylova, H. Sinn, et al.; collaboration: Inst. Cryst. Moscow, ESRF

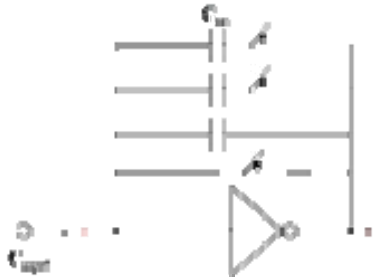
2D pixel detector developments

AGIPD Adaptive Gain Integrating Pixel Detector

⇒ dynamic gain switching

⇒ 1 analog pipeline





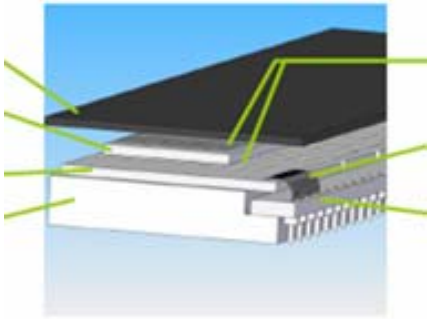
collaboration:

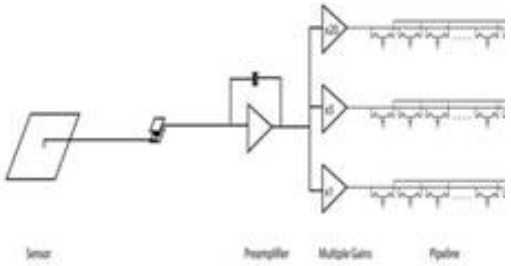
DESY, PSI, U Bonn, U Hamburg

LPD Large Pixel Detector

⇒ large dynamic range

⇒ 3 analog pipelines





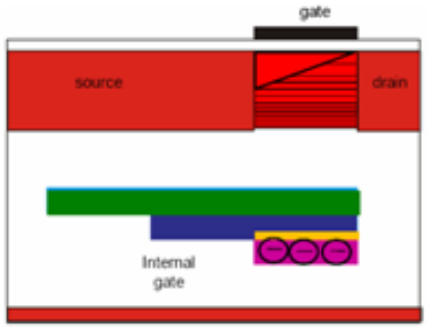
collaboration:

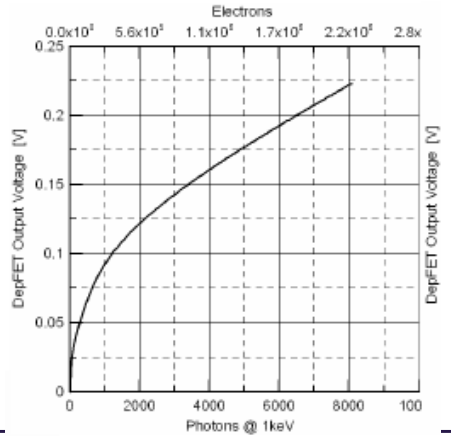
STFC/RAL, U Glasgow

DSSC DEPFET

⇒ non-linear amplification

⇒ soft x-ray sensitivity





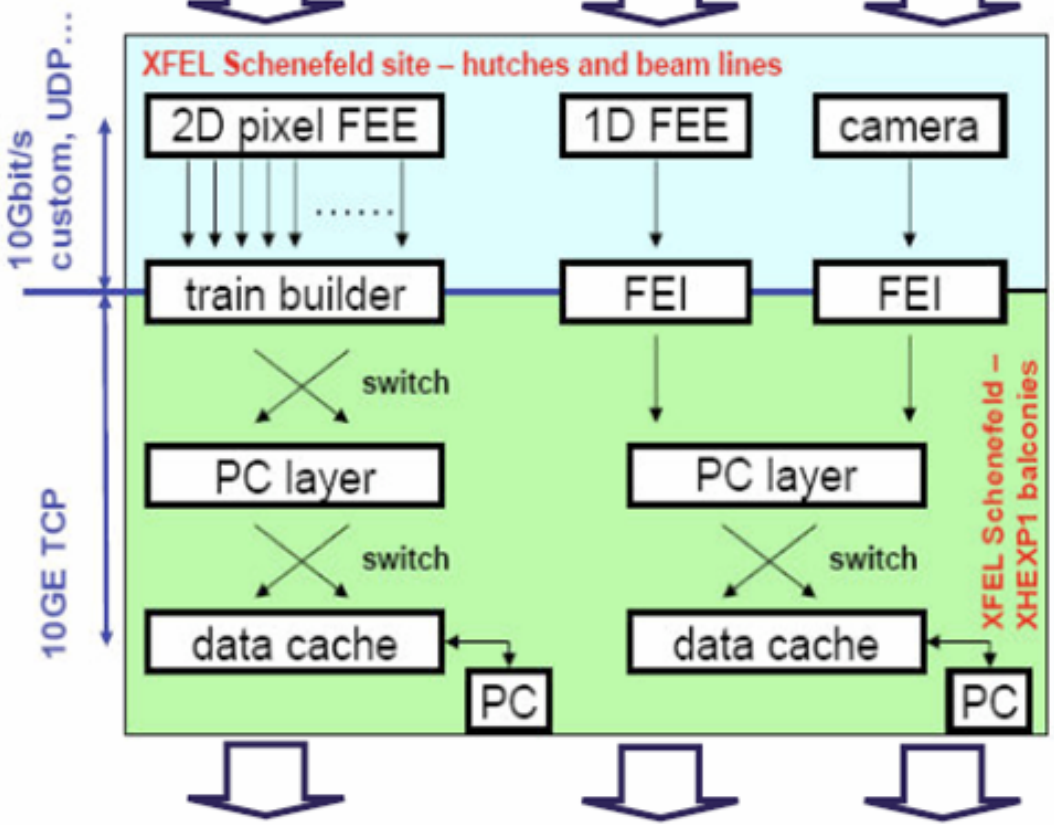
collaboration:

MPI-HLL, U Heidelberg, U Siegen, DESY, Politecnico di Milano, U Bergamo

Data acquisition/management (Ch. Youngman)

Typical throughput bandwidths:

Frame:	2MB	2kB	2MB
Train:	1GB	5MB	2MB
@PCL	10GB/s	50MB/s	20MB/s



Multiple layers per DAQ slice
= scalability and flexibility
Full write through speed to cache
= less if compressionl&reduction

Sub-system layers:

Front End Electronics FEE
Detector side interface to control & readout

Front End Interface FEI or TB
DAQ side interface to control & readout
Protocol conversion: custom to TCP
Frame and Train building
Data processing (= compression &I rejection)

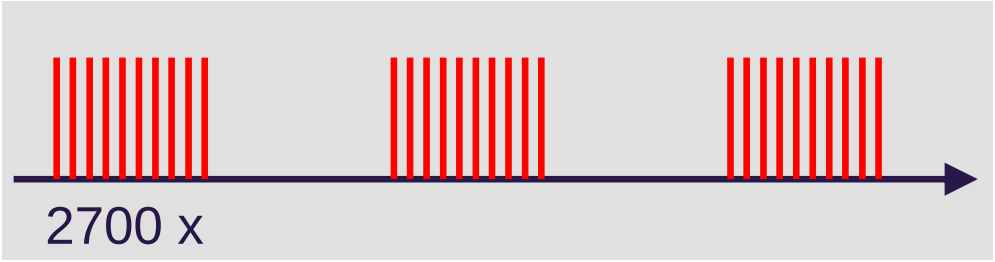
PC layer
On-the-fly data processing and monitoring
File formatting and aggregation

Data cache
2 day deferred commit to data archive
Processing, monitoring and quality control

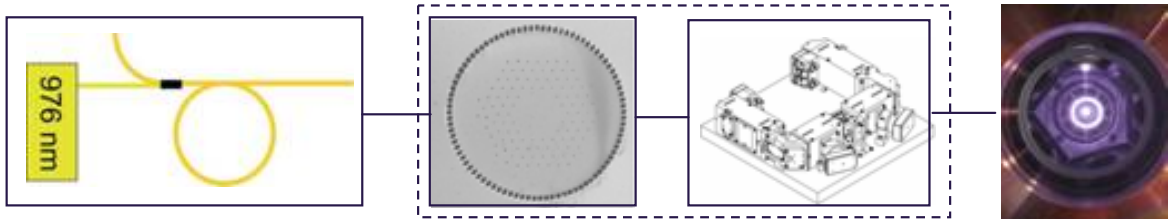
Max. cached data volume for 2D pixel DAQ slice: ≤ 2PB (2 days)

Optical lasers

- Challenge
  - burst-mode operation
  - high average power (>100 W)
  - ultrashort pulse



layout & test of pump laser



fiber preamplifier G=10³

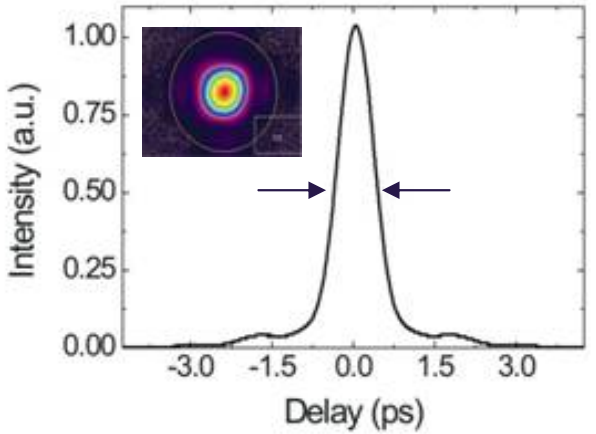
CPA fibre amplifier G>10⁴

Yb:YAG slab amplifier (G=100) 400W

Yb:YAG thin disk multipass

Amplifier tests (0.1 & 1 MHz)

- output power >350 W
- M^2~1.3, Δt= 800 fs FWHM



F. Tavella, S. Düsterer (DESY);

collaboration: DESY, HI Jena, ILT Aachen, MBI Berlin

Keeping contact with Users community of instruments

- Instrument workshops
  - consolidate science case and define requirements for design of beam transport and instruments
  - SQS – Nov ‘08, Aarhus
  - SPB – Nov ‘08, Uppsala
  - HED – Mar ‘09, Oxford
  - SCS – Jun ‘09, Villigen
  - MID – Oct ‘09, Grenoble
  - FDE – Dec 9-11, Budapest

Supported by EU FP7 Grant Pre-XFEL

European XFEL

International workshop for the Materials Imaging and Dynamics instrument at the European XFEL

28 – 29 October 2009

ESRF
Grenoble, France

The Materials Imaging and Dynamics (MID) instrument aims at the investigation of the nano-sized structure and nanoscale dynamics using coherent radiation. Applications to a wide range of materials from hard to soft condensed matter and biological structures are envisaged.

This meeting will present the scientific case but mainly focus on the technical specifications of the MID station. This will address in particular:
- source properties (energy range, polarization)
- experimental infrastructure (sample-chamber, temperature range, magnetic field, pump laser)
- 2-D detector system
- diagnostics, synchronization

This meeting forms part of a series of workshops aiming at the discussion of scientific cases and designs of the European XFEL instruments. It will feature a number of invited lectures presenting scientific and technical views, followed by group sessions providing opportunities for extended discussions from broad user communities on the construction of the MID instrument and its capabilities.

Young scientists bursaries
Deadline 28 September 2009
(for details see website)

The workshop is co-funded by the European Commission through the Pre-XFEL grant. This will allow free of charge access to the workshop.

Hosting the workshop and support by the ESRF, Grenoble, France, is gratefully acknowledged.

Local organizer
Anders Madsen
European Synchrotron Radiation Facility ESRF, Grenoble, France

International programme comm
Jeroen Goodkoep, Van der Waals-Zeem Instituut, Amsterdam, Netherlands
Gerhard Grübel, DESY, Hamburg, Germ
Olivier Thomas, Université Paul Cézanne Marseille, France
Thomas Tschentscher, European XFEL, Hamburg, Germany
Ivan Vartaniants, DESY, Hamburg, Germ

www.xfel.eu/mid-workshop-200
Registration deadline
19 October 2009

Contact
Anders Madsen
amadsen@esrf.fr
European Synchrotron Radiation Facility E
38043 Grenoble-Cedex, France

Organisational issues
Imke Gembalies
imke.gembalies@xfel.eu

www.xfel.eu

European XFEL

International workshop series on the science and instrumentation at the European XFEL:

Femtosecond X-Ray Experiments

9 – 11 December 2009

KFKI Research Institute
Budapest, Hungary

The Instrument for Femtosecond X-Ray Experiments (FDE) will exploit the unique time structure and intensity of the European XFEL for structural dynamics studies of molecules, biological species and solid state materials. This instrument will allow new investigations of electronic and atomic structure changes that are not possible today. It will thus supplement to several fields of contemporary research including chemical and biological dynamics and solid state physics. Advanced X-Ray Spectroscopies and Scattering will be implemented with femtosecond time resolution, but also techniques that require the intense average XFEL flux are foreseen.

This meeting forms part of a series of workshops aiming to discuss scientific cases and designs of the European XFEL instruments. It features a number of invited lectures on scientific and technical aspects, followed by group sessions providing opportunities for extended discussions from broad user communities on the construction of the FDE instrument and its capabilities.

Young scientists bursaries
Deadline 15 Oct 2009
(for details see website)

The workshop is co-funded by the European Commission through the Pre-XFEL grant. This will allow free of charge access to the workshop.

Hosting the workshop and support by the KFKI Research Institute, Budapest, Hungary, is gratefully acknowledged.

Local organizers
György Vankó, Dénes Nagy
KFKI Research Institute, Budapest, Hungary

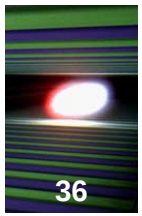
International programme committee
Matias Bargheer, University of Potsdam, Germany
Christian Bressler, European XFEL Project Team, Hamburg, Germany
Gyula Faigel, KFKI Research Institute, Budapest, Hungary
Pieter Glatzel, ESRF, Grenoble, France
Steven Johnson, Swiss Light Source, Villigen, Switzerland
Martin Nielsen, University of Copenhagen, Denmark
Alexander Soldatov, Rostov University, Russian Federation
Simone Techert, MPI Göttingen, Germany

www.xfel.eu/fxe-workshop-2009
Registration deadline
01 Nov 2009

Organisational issues
Imke Gembalies
imke.gembalies@xfel.eu
European XFEL
Hamburg, Germany

www.xfel.eu

European XFEL science program



LCLS had a perfect start and has brought expectation level ‘high’

Scientific applications using hard X-rays will start 2010

- Request for beam time seems to be extremely high
- European scientists make an important impact
- LCLS program will ramp up 2010 – 2012

European XFEL can start its experimental program 2015

- Improve instrumentation based on LCLS experience
  - ➔ by collaborations and sending people
  - ➔ by scientific applications
- Higher repetition rates will enable additional classes of experiments

European XFEL offers several possibilities for extension

- more sources/undulator options/instruments
- additional fan of beam lines
- superconducting technology enables other operation modes

Thanks

To Thomas Tschentscher, Joachim Pflüger and Serge Prat

for help in the preparation of this talk

...and to you

for your attention