The European XFEL Project

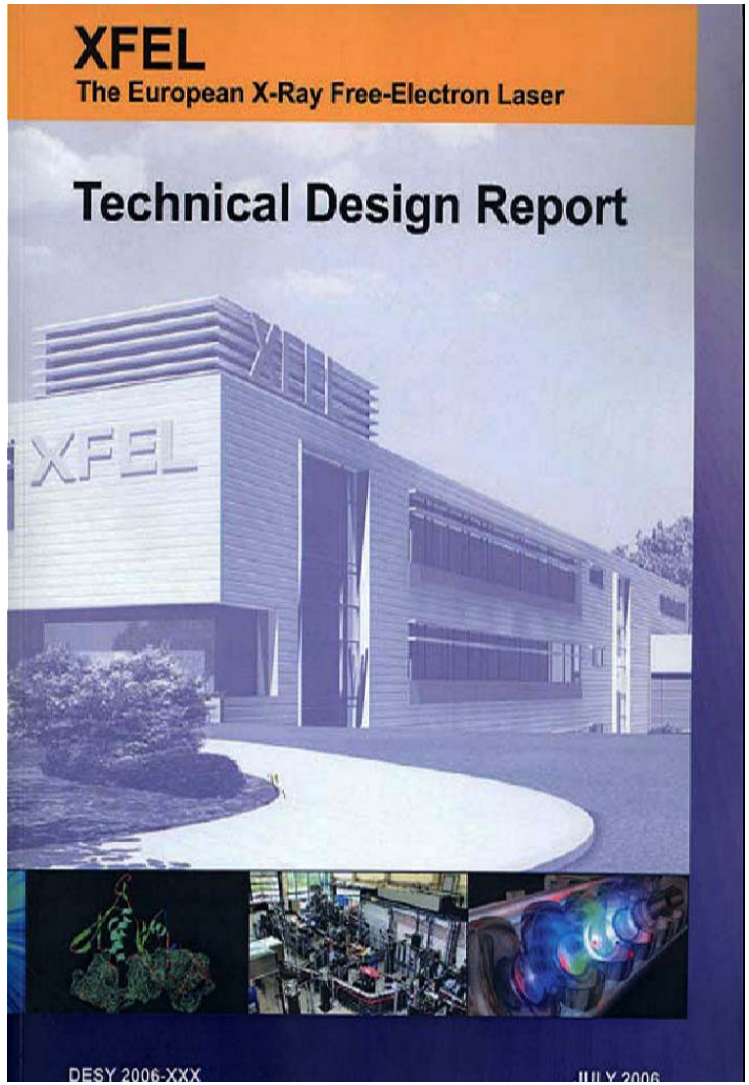
Light for the Future

Introduction

- Proposal Oct. 2002 –X-ray FEL user facility with 20 GeV superconducting linear accelerator in TESLA technology
- Approval by German government Feb. 2003 as European Project
- Commitment for 50% of funding + 10% by Hamburg & Schleswig-Holstein, 40% European & international partners (23% Russia)

Time schedule

- March 2006: Review of Accelerator & Infrastructure parts
- Civil Construction started 2009
- Christmas 2009:
  XFEL Company founded (GmbH)
  In-kind Contributions
  Negotiations and Contracts
- First beam 2014
- Start of user operation 2015



Politics – how to built an accelerator

German Minister of Science and the Town Mayor of Hamburg

Politics – how to built an accelerator

The Prime Minister of Schleswig-Holstein wants to join ….

Politics – how to built an accelerator

This way?

Politics – how to built an accelerator

No, more precise, please

Politics – how to built an accelerator

Ufff, we got it, it was so easy.

And this physicists want 1 Billion Euros for this?

Convention concerning the Construction of a European X-ray Free-Electron Laser Facility

30th November 2009,

10:15 am

banquet room

Hamburg's town hall

30th November 2009, 10:15 am in the banquet room of Hamburg's town hall
Representatives from Denmark, Germany, Greece, Hungary, Italy, Poland, Russia, Slovak Republik, Swedenand Switzerland (Spain and France), China; UK plans

Contributions of countries (other than Germany)

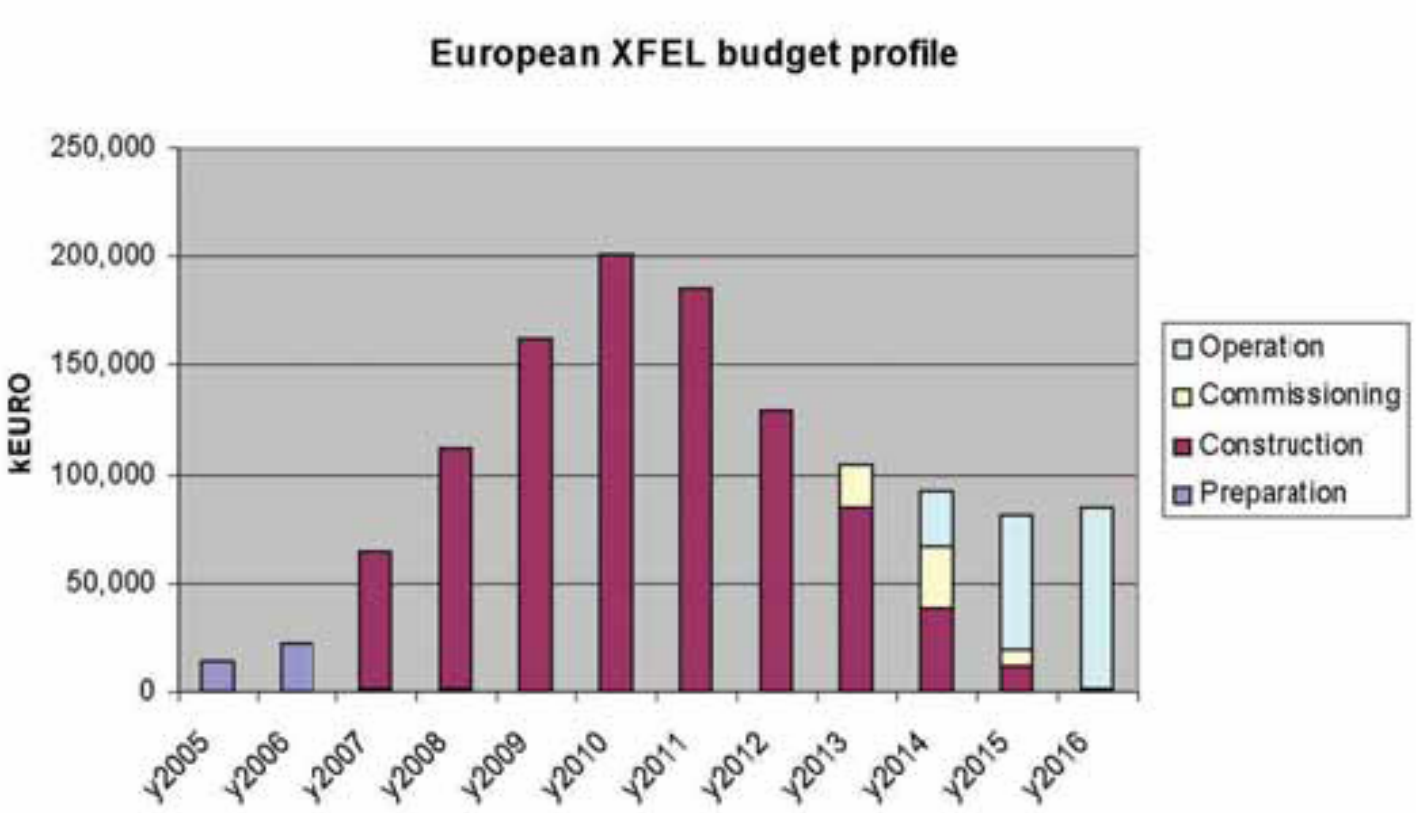
WPG1 Linac	WPG1 Linac	WPG2 Accelerator Subsystems	WPG4 Control & Operation	WPG5 Infrastructure	WPG3 Photon Beam System	WPG3 Photon Beam System	WPG6 Sites & Buildings
WP01 RF System *Stefan Choroba*	WP07 Freq. Tuners *L. Lilje / A. Bosotti*	WP12 Warm magnet *Bernward Krause*	WP28 Acc Control Sys. *Kay 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 St. 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*					

RU ES SE CH FR IT PL

Russian Contribution to XFEL

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

Politics – spending money



Still Money and Politics

- Project preparation 38.8 M€
- *Project construction, capital investment 736.3 M€*
- *Project construction, personnel 250.1 M€*
- **Total construction cost 986.4 M€**
- Beam commissioning 56.4 M€
- **Total project construction cost 1,081.6 M€**

The European XFEL will be constructed
and operated by the European XFEL GmbH,
a non-profit Company of Limited Liability under German law.
This company was founded on 28 September 2009

Hierarchy of XFEL GmbH

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

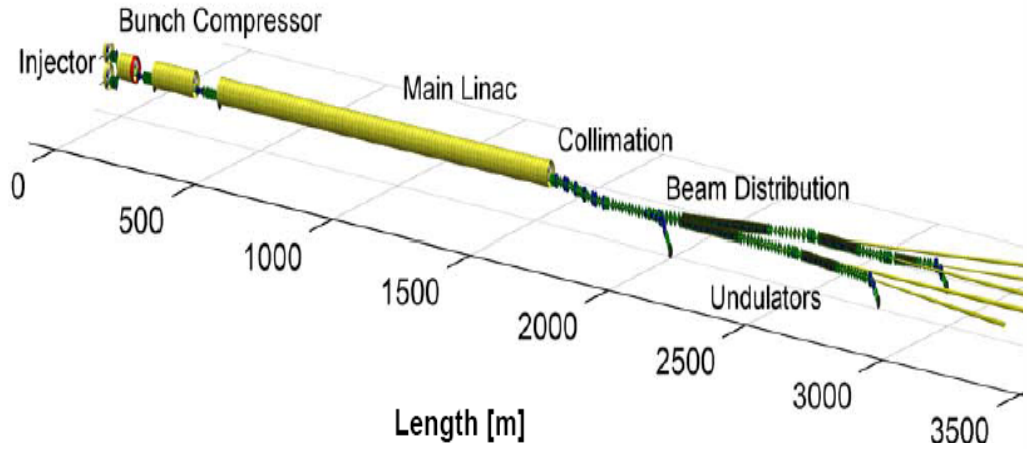
MAC

AFC

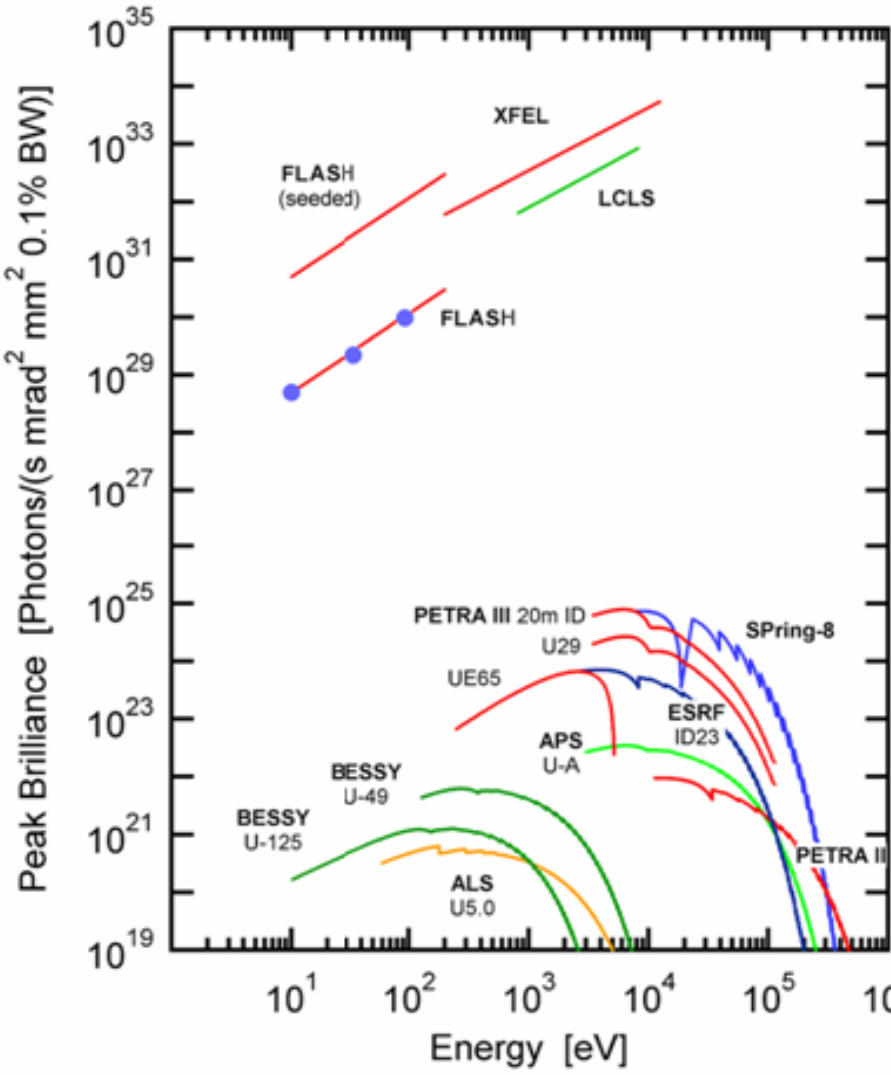
IKRC

Accelerator Layout

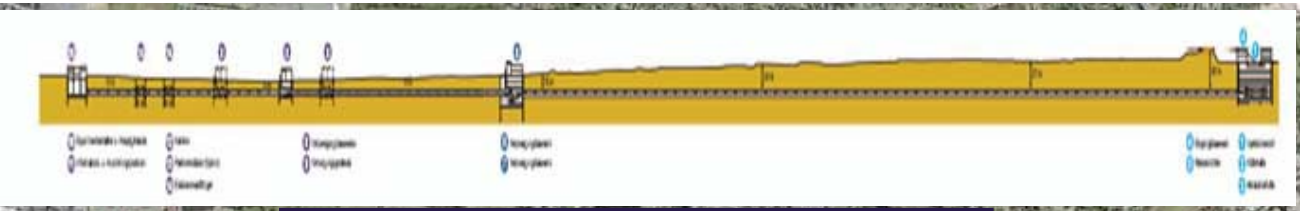
- 17.5 GeV superconducting LINAC
- RF photoinjector, two bunch compression stages
- 3 SASE undulators plus 1 spontaneous source, extension possible



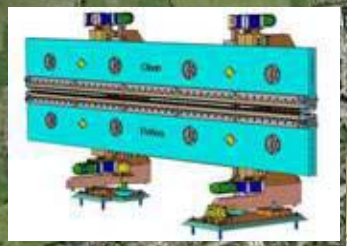
- 5 experimental stations to be extended to 10
- potential extension with a second experimenta

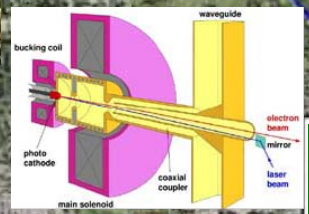


Birds View



Actual position of tunnel boring machines.
The positions are updated every morning





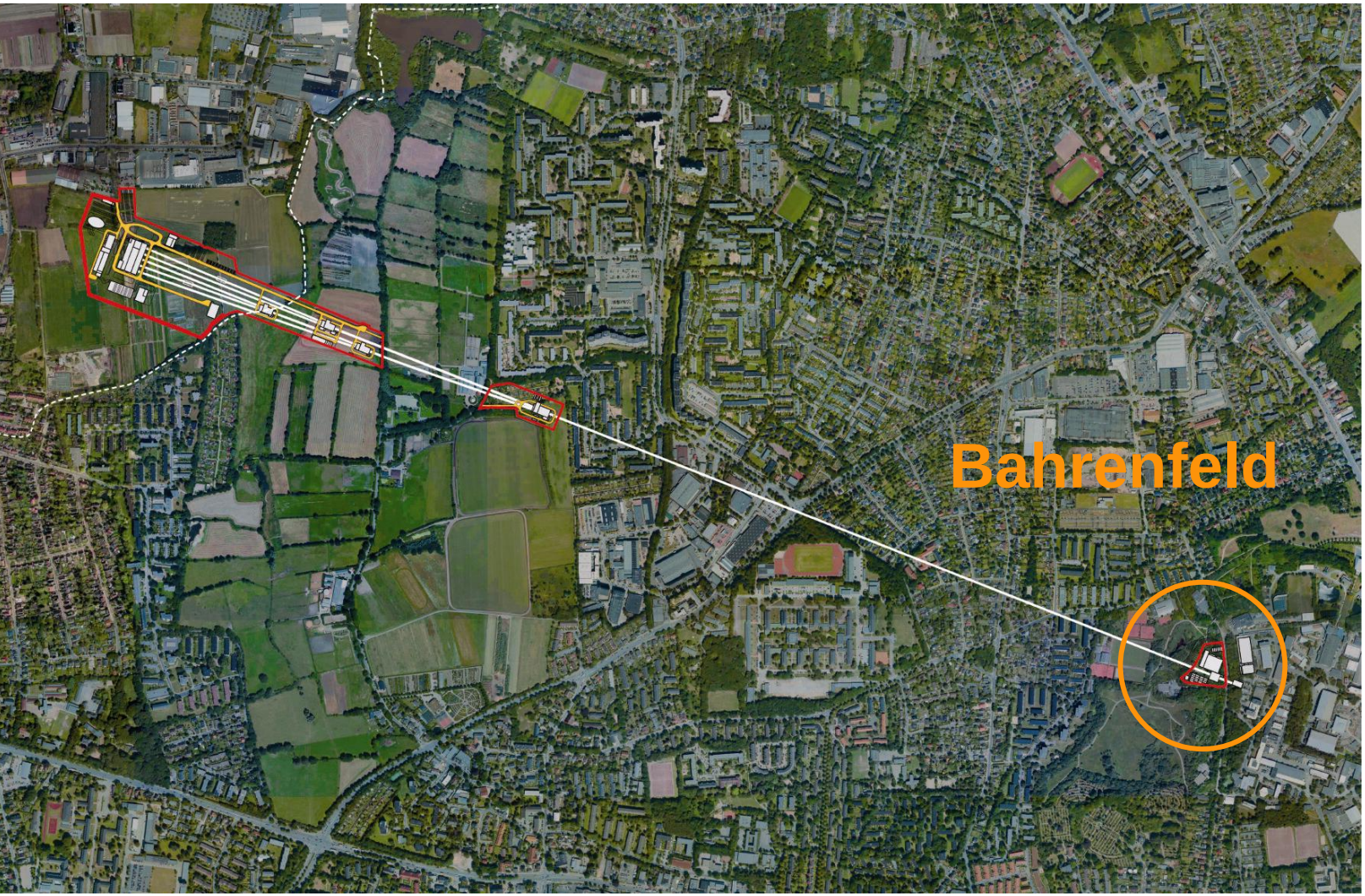
HERA

PETRA III

FLASH

Hamburg
Centre 7 km

WEBCAMS: http://www.xfel.eu/project/webcams



Bahrenfeld – 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

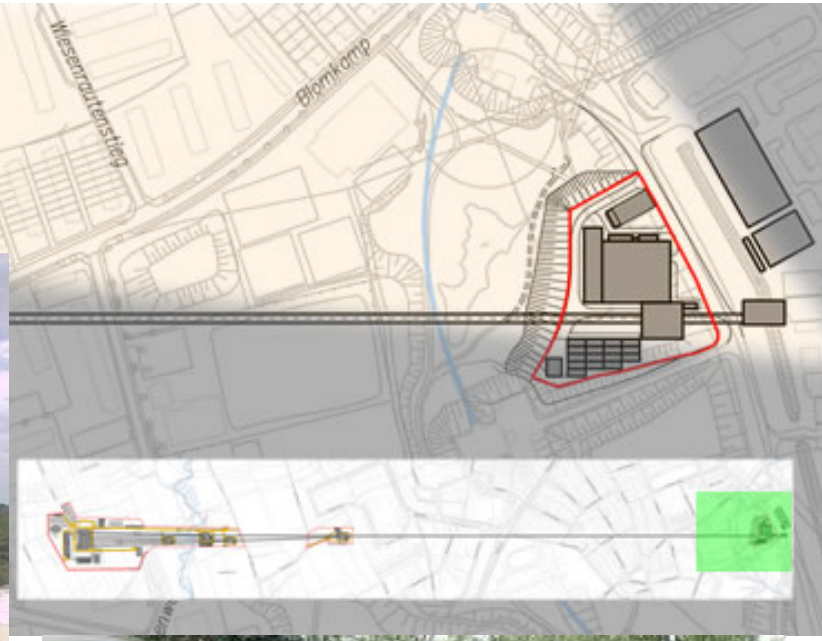
height: 11m

linac tunnel

soil above tunnel: ~ 35 m

WEBCAMS: http://www.xfel.eu/project/webcams

The very beginning – Bahrenfeld with gun



The Gun – PITZ in DESY - Zeuthen

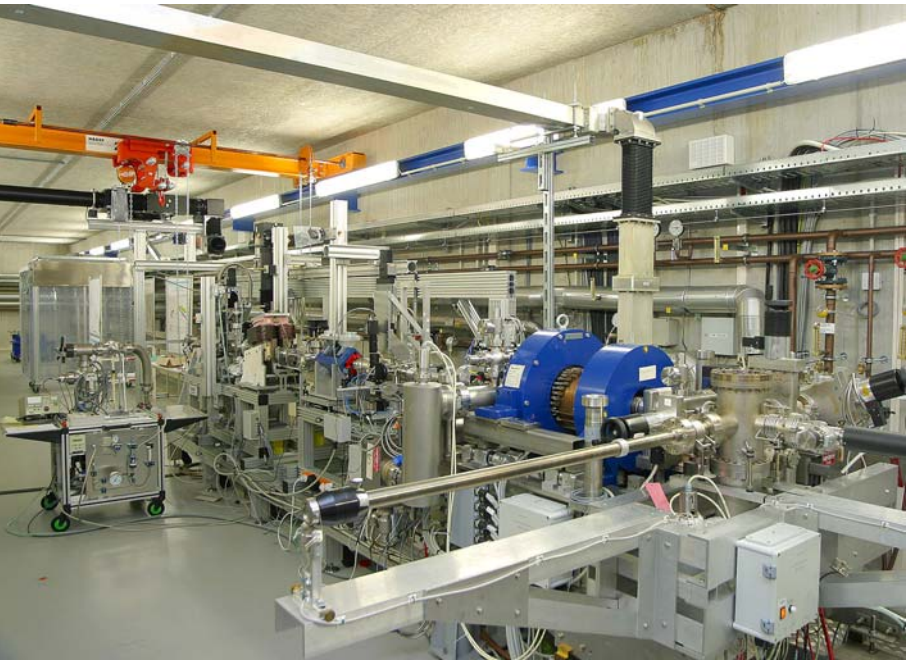
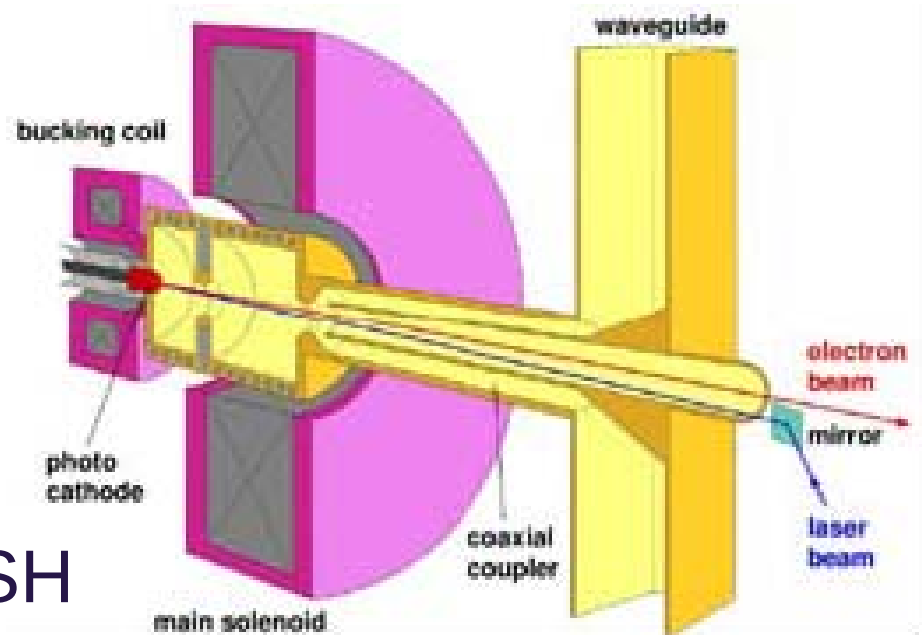
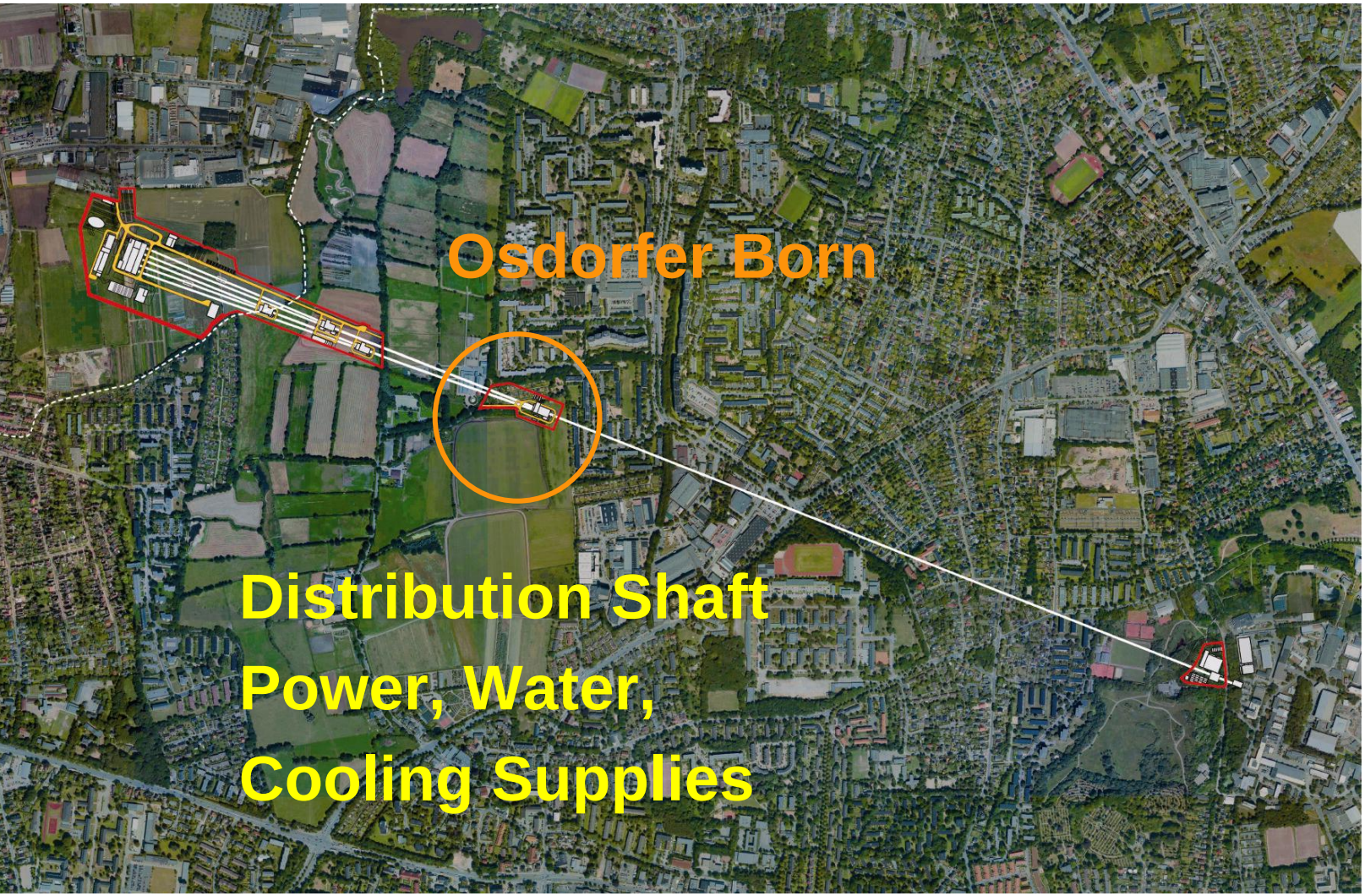


Photo Injector Test facility in Zeuthen

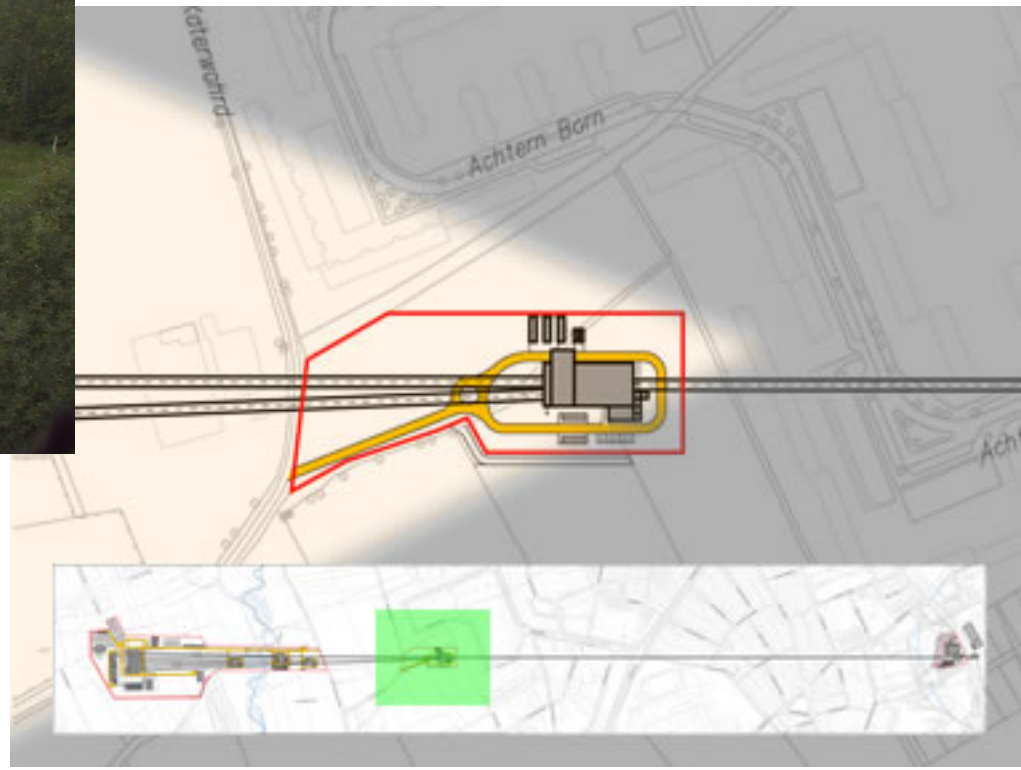


Delivers the Guns for FLASH and in future for XFEL

WEBCAMS: http://www.xfel.eu/project/webcams



- Osdorfer Born



European XFEL

WEBCAMS: http://www.xfel.eu/project/webcams

European XFEL

Schenefeld site - before

European XFEL

Schenefeld site in future

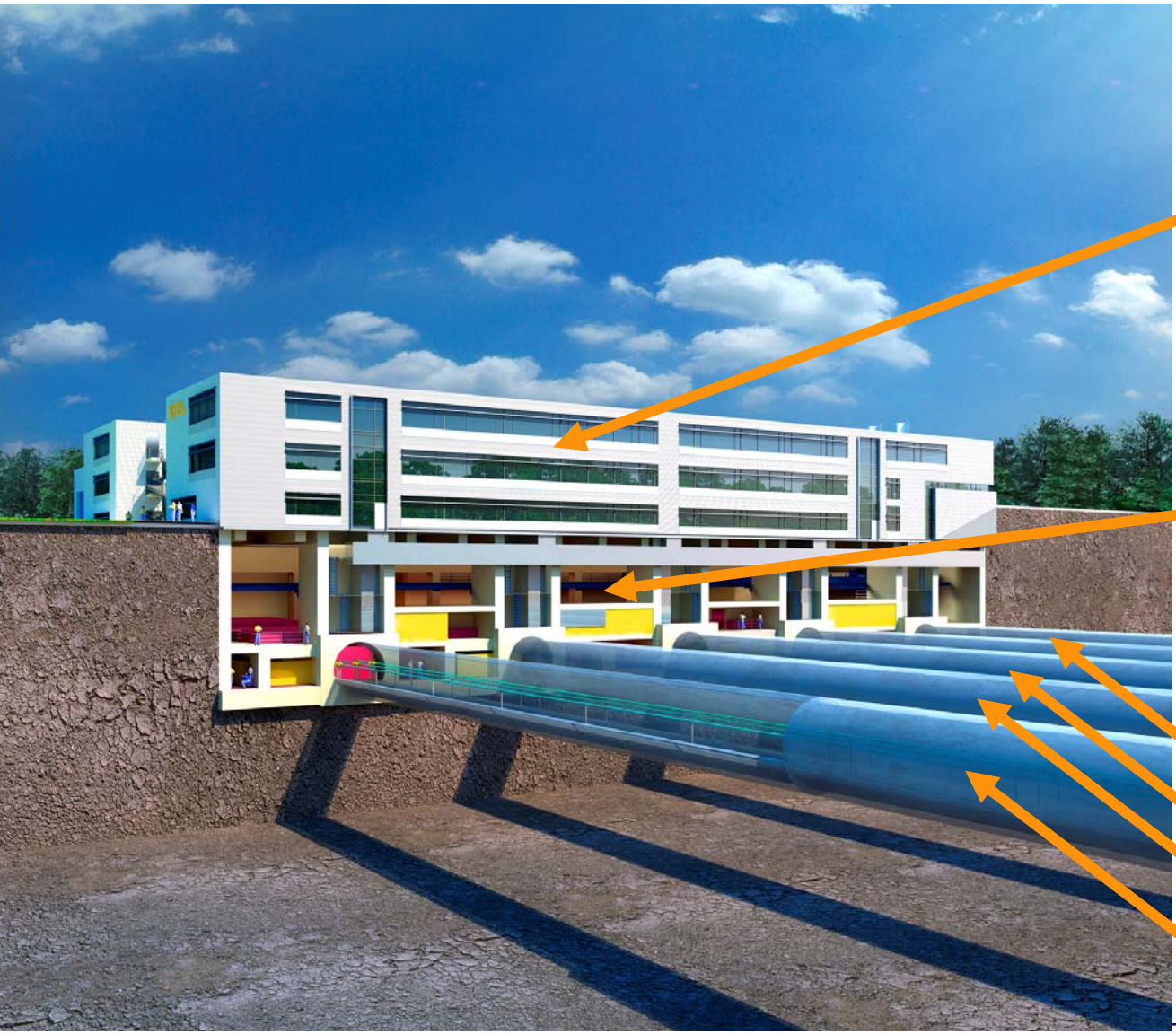
WEBCAMS: http://www.xfel.eu/project/webcams

Schenefeld

Experimental Hall

Experimental Hall in Schenefeld

Tunnels with Experimental Hall



The Tunnel

Tunnel Length ~ 3.3 km

Tunnel boring machine (called TULA = TUnnel for LAser)

The Tunnel

Down into the pit

First Day of Operation

Celebration of First Tunnel Boring

Big Fete

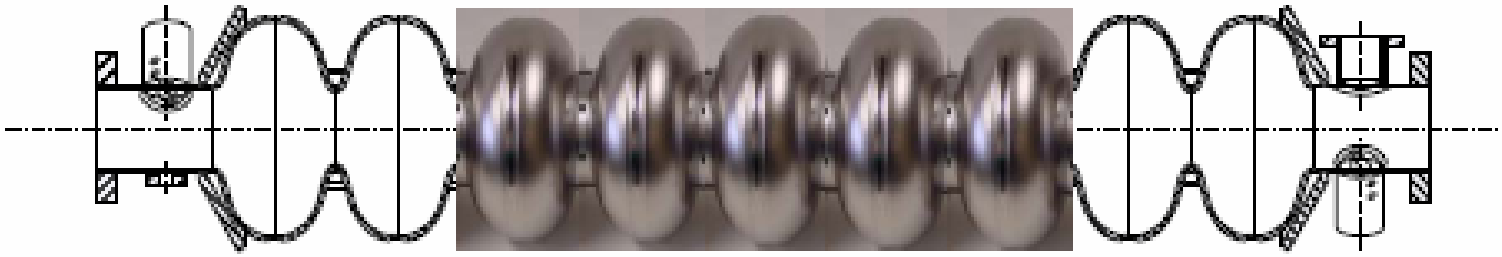
Tunnel Boring Progress today:

8.4% (see www.xfel.eu)

Congratulations

Key Component: Superconducting TESLA Cavities

cavity material		RRR 300 niobium
type of accelerating structure		standing wave
accelerating mode		TM010, π-mode
fundamental frequency	f_{RF} [MHz]	1,300
active length	L [m]	1.038
nominal gradient	E_{acc} [MV/m]	23.6 (35)
quality factor	Q_0	$>10^{10}$
cell-to-cell coupling	K_{cc} [%]	1.87
iris diameter	[mm]	70



- Series production in Industry
- “Problem cases” cured at DESY

News from 7th September 2010

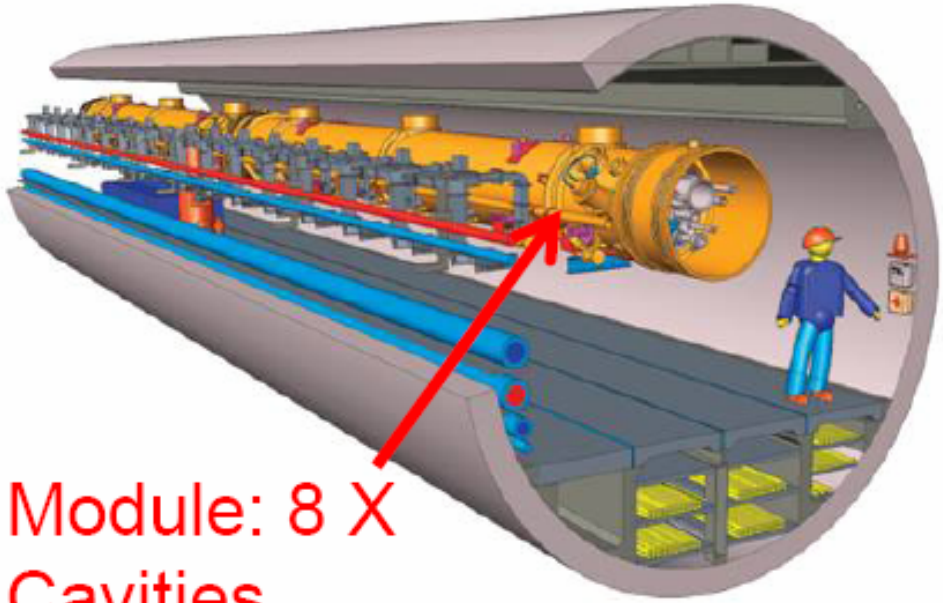
European XFEL accelerator components go into production

50 MEuro
a German and
an Italian firm
produce each
300 cavities
between 2012
and 2014

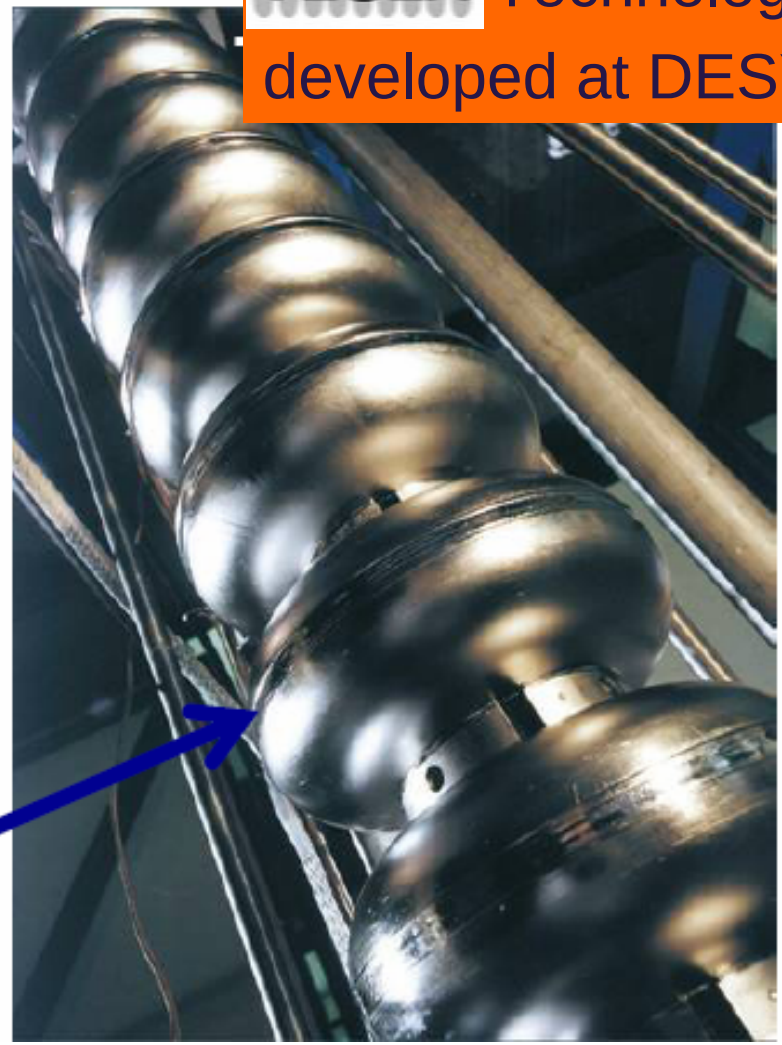
Superconductiong Cavities

TESLA Technology developed at DESY

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



Module: 8 X Cavities



Niobium Cavities

PXFEL1 – First Prototyp for XFEL

Cryogenic Module

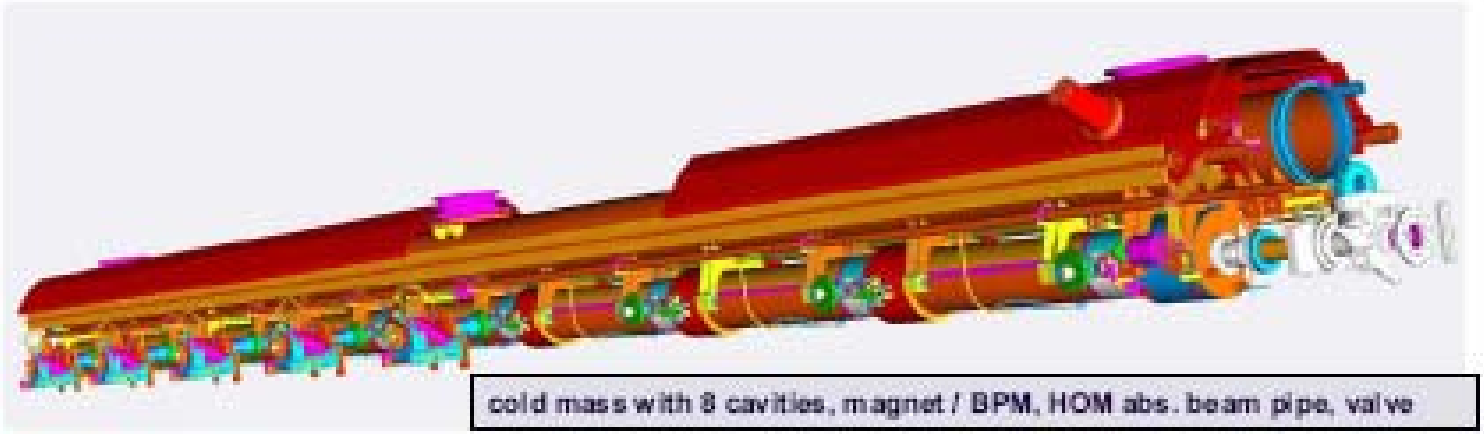


Institute of High Energy Physics
Chinese Academy of Sciences

duro felguera, s.a.

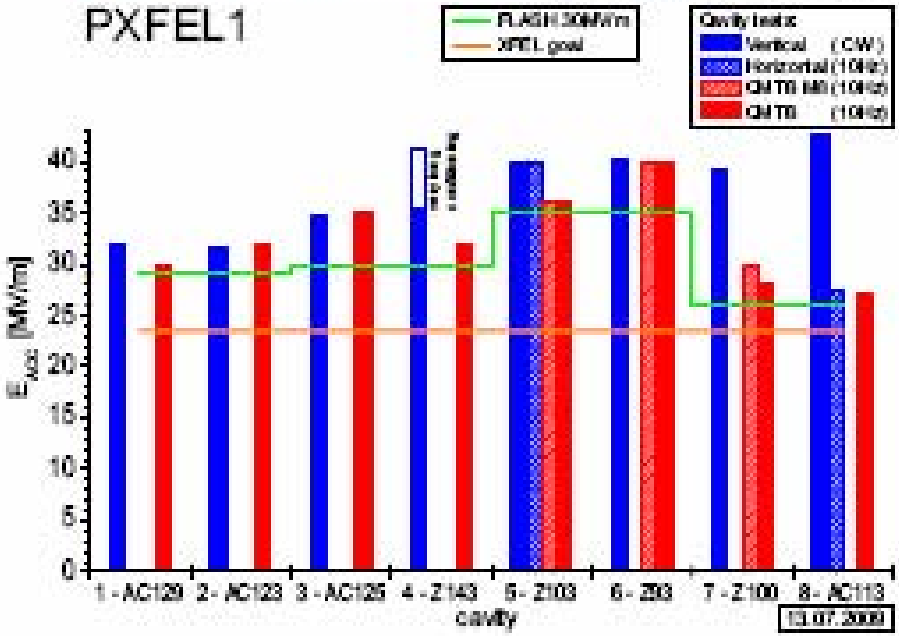
THALES


Cavities in Cryogenic Module



cold mass with 8 cavities, magnet / BPM, HOM abs. beam pipe, valve

PXFEL1



PXFEL1 (XFEL Prototype)

- Average maximum gradient is 32.5 MV/m.
- PXFEL1 will be installed at FLASH and can be operated there with an average gradient of 30 MV/m.
- The XFEL waveguide distribution will be used.

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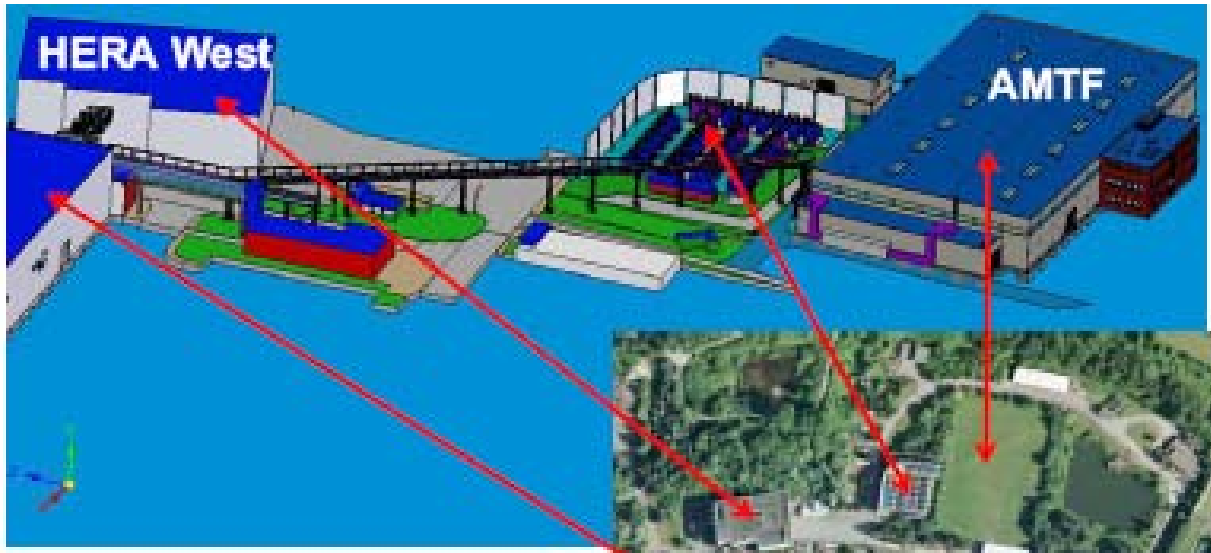
Tesla Technology – Prototyp PXFEL1

Accelerator Module Test Facility

101 accelerator modules to be built



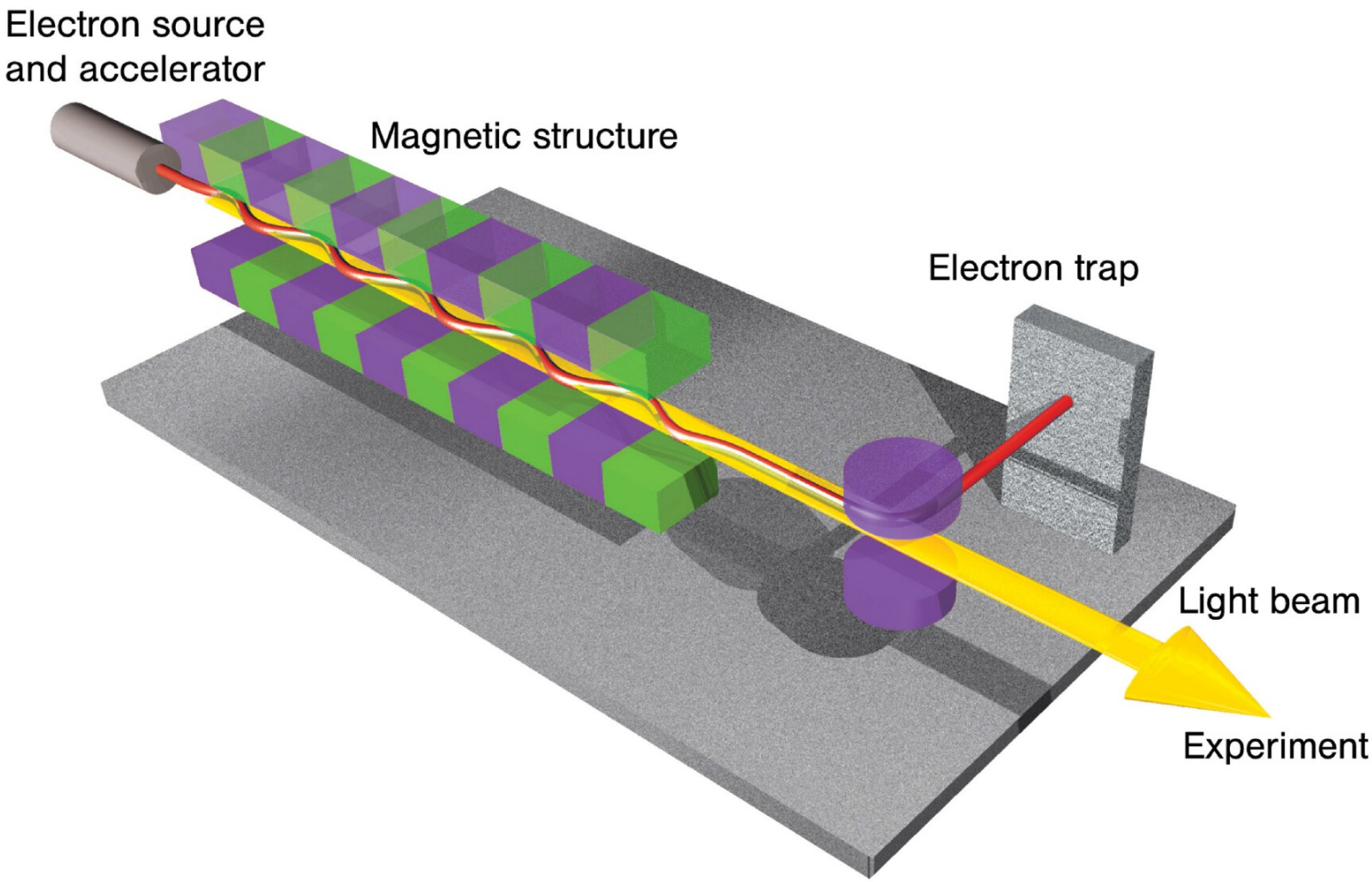
- Civil construction started, First series modules on teststands mid 2011

Wroclaw Univ., INP Cracow

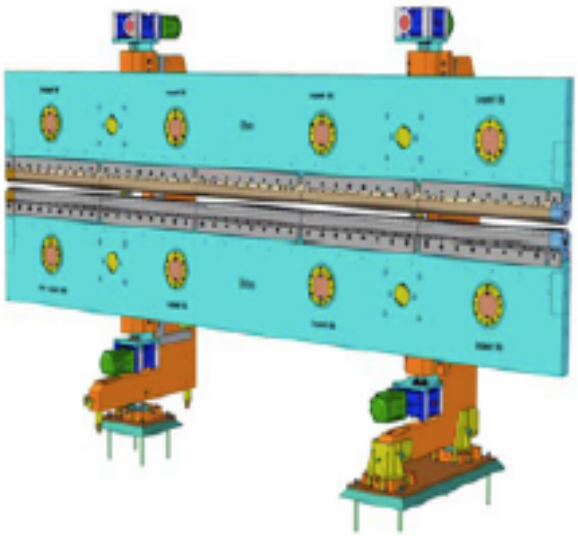
DESY

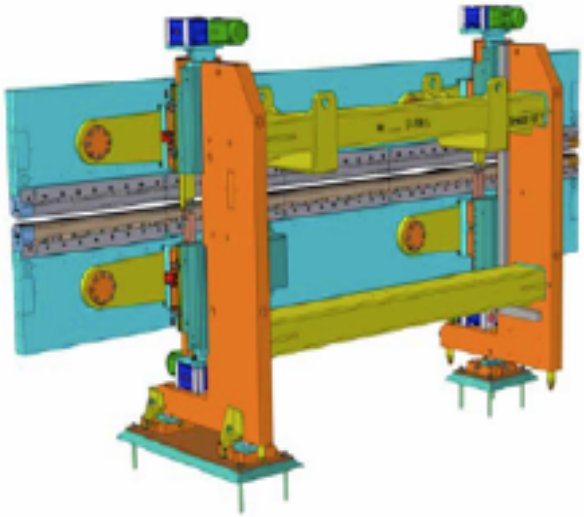
BINP/Novosibirsk, IHEP/Protvino

How to Create Light?

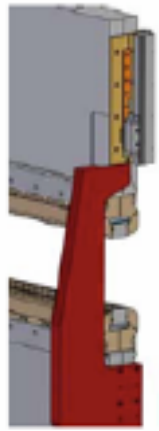


Flexible Undulators





Gap Measurement
Accuracy ±1µm

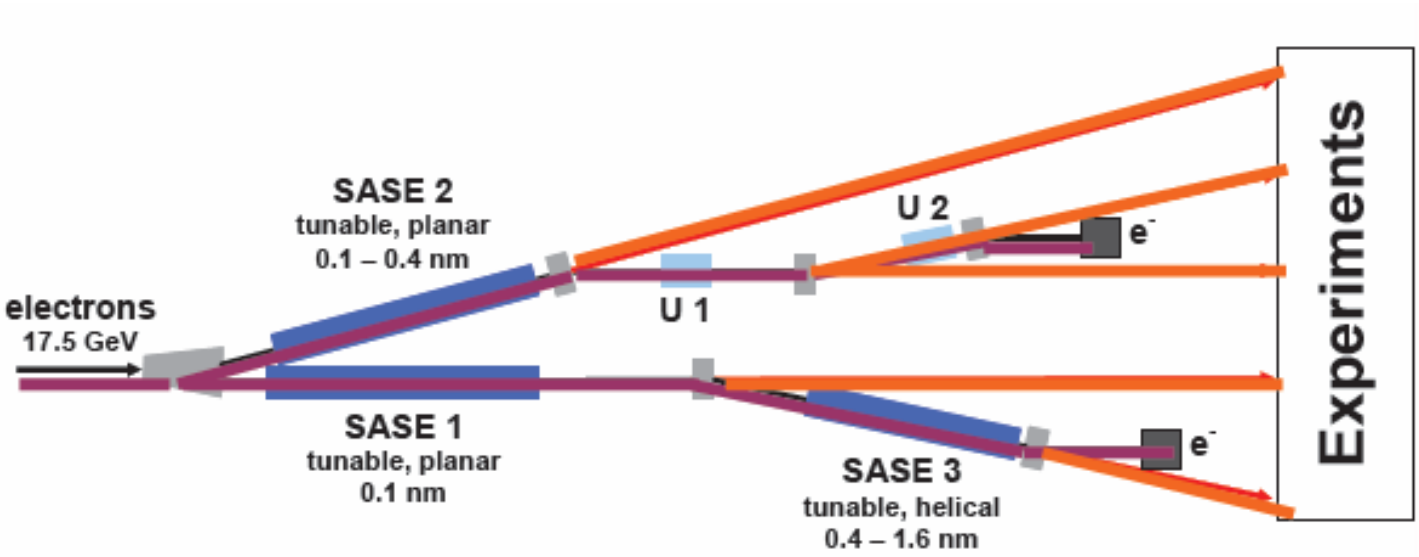


Special Attention:

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

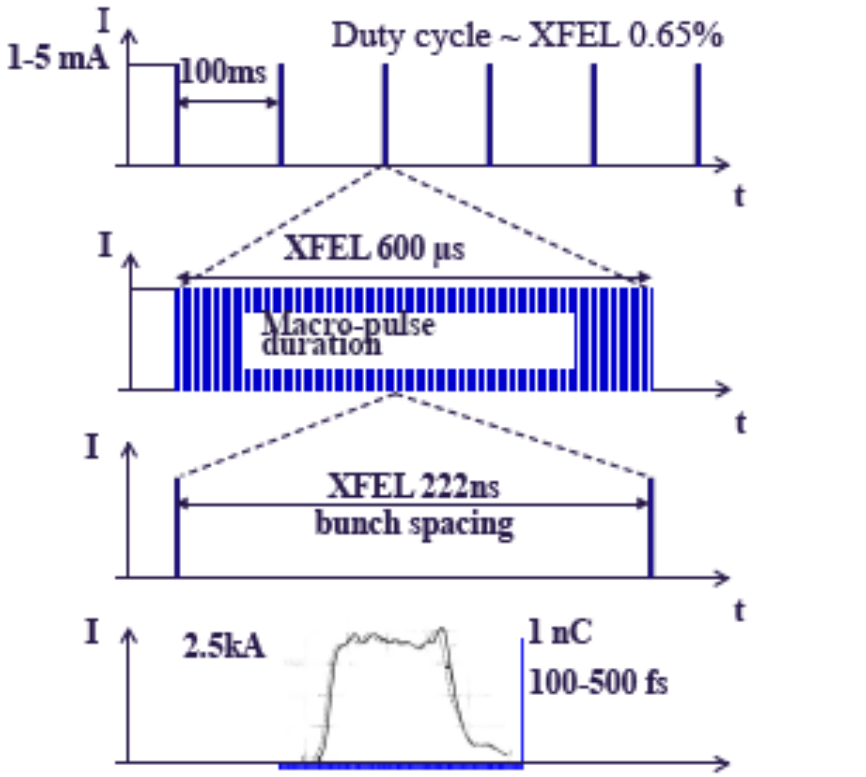
Undulators at the End of the Linac

- **17.5 GeV create 0.1 nm Laser**
- **Variation (0.1 – 1.6 nm) possible**



XFEL Time Structure: High Duty Cycle

- Repetition rate
- Macro pulse
- Bunch
- Slice
- Up to 27000 Bunches/s



FLASH and E-XFEL will have the same time structure

And, what now?

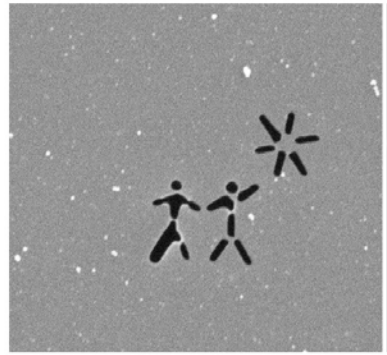
We have the most brilliant,

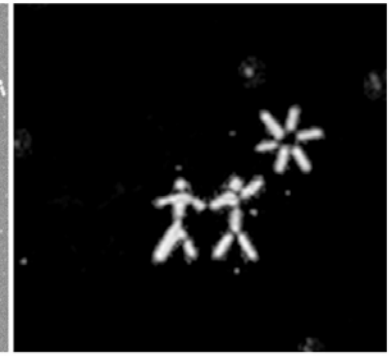
shortest Laser Light

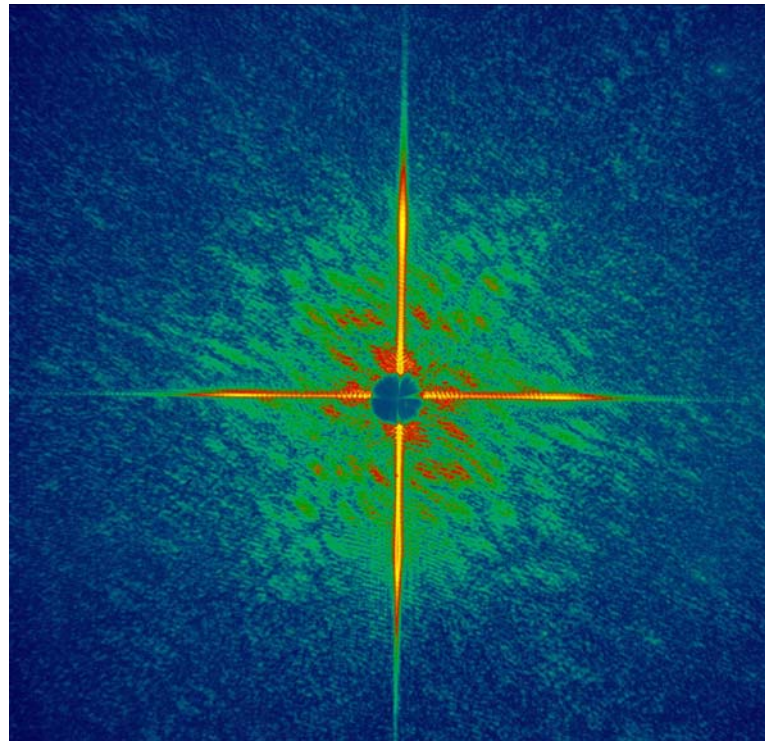
Hat can we do with this?

Exploring the nanoworld in 3D

The next generation of magnetic storage devices, for instance, will comprise structures that are smaller than 100 nanometres. At this level, materials exhibit astonishing new properties: copper becomes transparent, aluminium inflammable, gold liquid, silicon conductive.



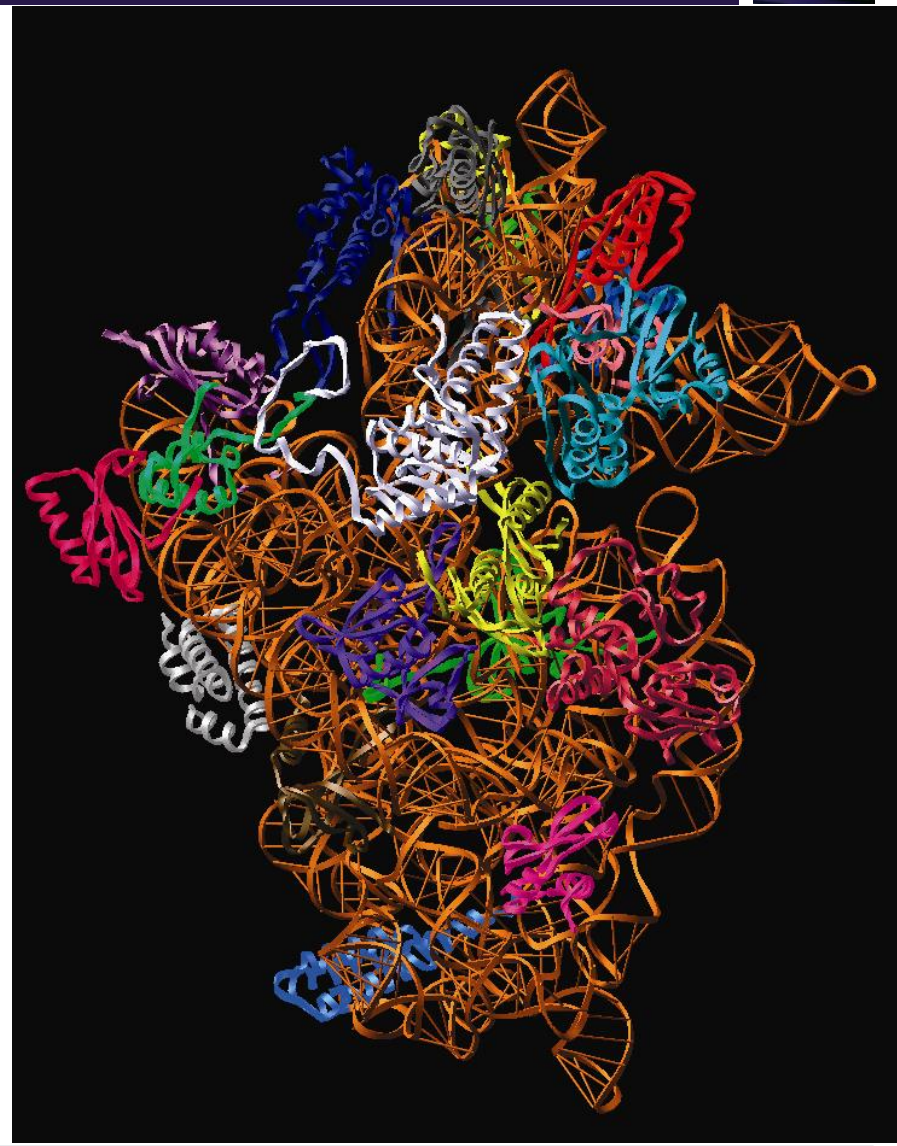




Deciphering the structure of biomolecules

Ribosomes are large molecular complexes that act as "protein factories" and occur in every cell. The X-ray laser opens up completely new opportunities to interpret such biological structures with atomic resolution

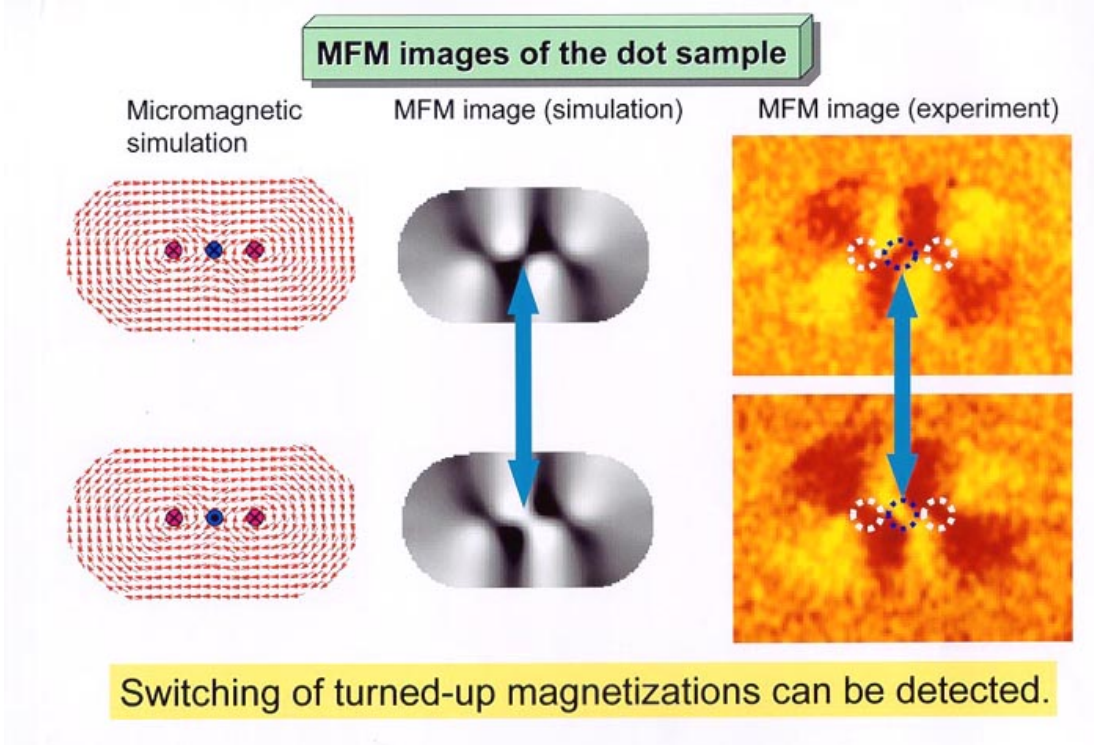
Remember: – Ada Yonath
Nobel prize Chemistry 2009



Unravelling magnetization

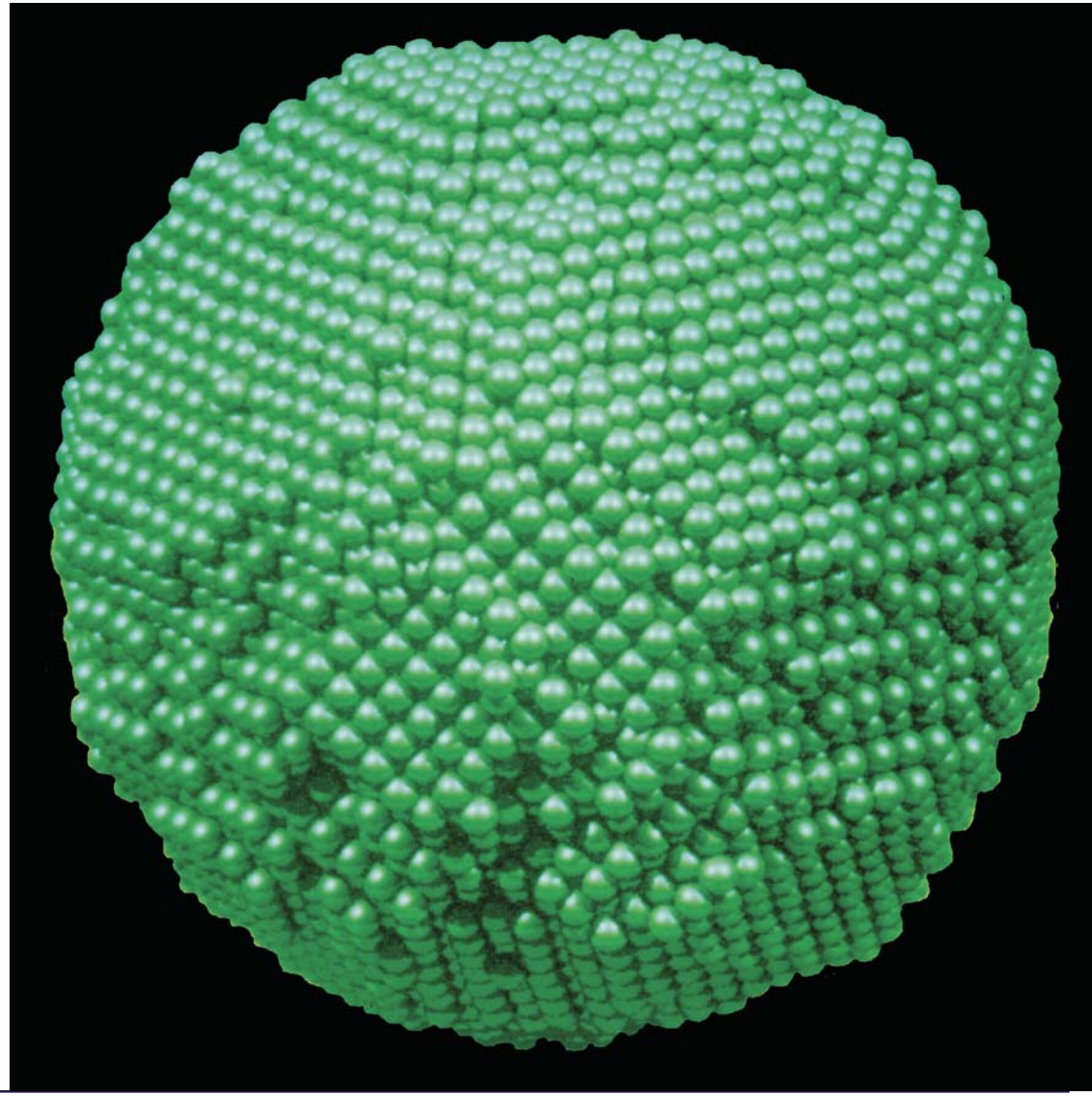
- Understanding better how magnetization is created and how it can be reversed is especially interesting for the miniaturization of electronic devices

When materials reverse their magnetization, this is due to a complex interplay of the electrons in the materials.
Using the X-ray flashes these incredibly fast processes can be studied



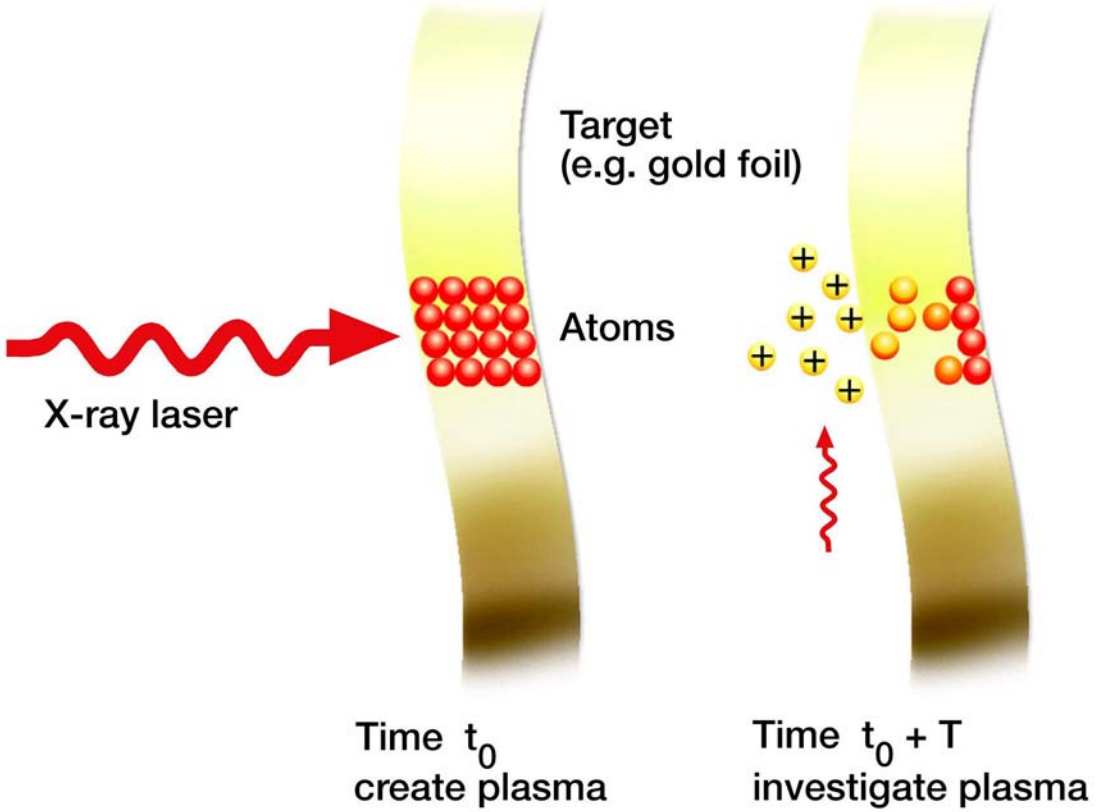
Observing small objects in strong fields

Clusters are tiny collections of atoms or molecules. The picture shows the model calculation of a copper particle with the size of 17000 atoms - a cluster which plays a role in catalytic processes



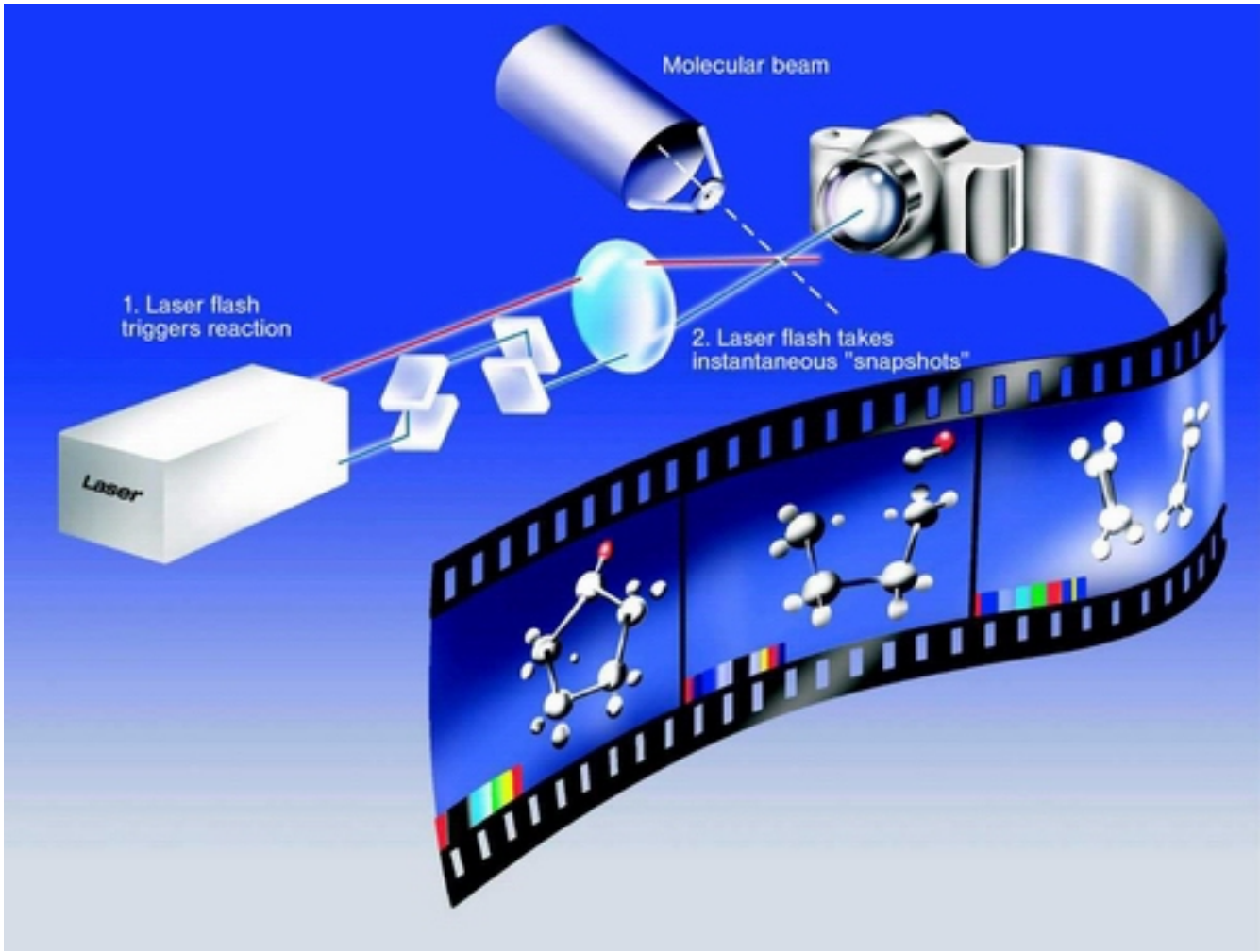
Investigating extreme states of matter

The X-ray flashes are so intense that they can be used to create pressures and temperatures similar to those in the interior of planets.



The scientific dream – slow motion

Make movies from chemical and biological processes



- The End