The road to the European XFEL

Jochen R. Schneider

Deutsches Elektronen-Synchrotron DESY
Center for Free-Electron Laser Science CFEL

Milestones

Key scientific papers:

1980 **A.M. Kondratenko, E.L. Saldin**
"Generation of Coherent Radiation by a Relativistic Electron Beam in an Undulator"
Part. Accelerators 10, 207 (1980)

1984 **R. Bonifacio, C. Pellegrini, L.M. Narduci**
"Collective Instabilities and High-Gain Regime in a Free-Electron Laser"
Opt. Communications 50, 373 (1984)

2003 **German Federal Ministry of Education and Science announces to pay half of the cost of the free-electron laser facility proposed by DESY which should be realized in a European collaboration**

2008 **Contracts for underground construction of the tunnels and the associated buildings of the European XFEL were awarded**

2009 **Establishment of European XFEL under international law by 10 European Countries**

2009, November 30

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

2009, November 30

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

Congratulations

Massimo Altarelli ***Karl Witte*** ***Andreas Schwarz*** ***Thomas Tschentscher*** ***Serguei Molodtsov***

The road to European XFEL

15 years of "walking on thin ice" with a fascinating interplay between science, technical progress, politics, and outreach to administrations and the public

- ***driving forces** in the early stages of the project*
- ***DESY** and the international **TESLA** collaboration*
- ***discussions on the European level, from ELFG (D,F, I, Sp, UK) to ESFRI***
- ***political decisions made in Germany***
- ***MoU for the preparatory phase of the European XFEL signed by 13 countries in January 2005***
- ***Committees: ISC, STI, AFI***
- ***European XFEL Convention 2009***

Jochen R. Schneider
jochen.schneider@desy.de

Driving forces in the early stage

Scientific Workshops

1986 *ICFA workshop on low emittance e- - e+ beams (BNL)*

J.B. Murphy and C. Pellegrini

1990 *Workshops on prospects for a 0.1 nm free-electron laser (BNL)*

R. Palmer, W. Willis, J.G. Gallardo

1992 *Workshop on Forth Generation Light Sources (SLAC)*

M. Cornacchio and H. Winnick

Examples of FELs operating from 100 nm to 0.1 nm producing peak power from 0.65 MW to 5 GW using linacs of 0.325 GeV to 50 GeV were developed by the working group and are listed in their summary. These included the use of the SLAC linac equipped with low emittance guns to drive 4 nm to 0.1 nm FELs.

1992 ***Workshop on Scientific Applications of Short Wavelength Coherent Light Sources (SLAC)***

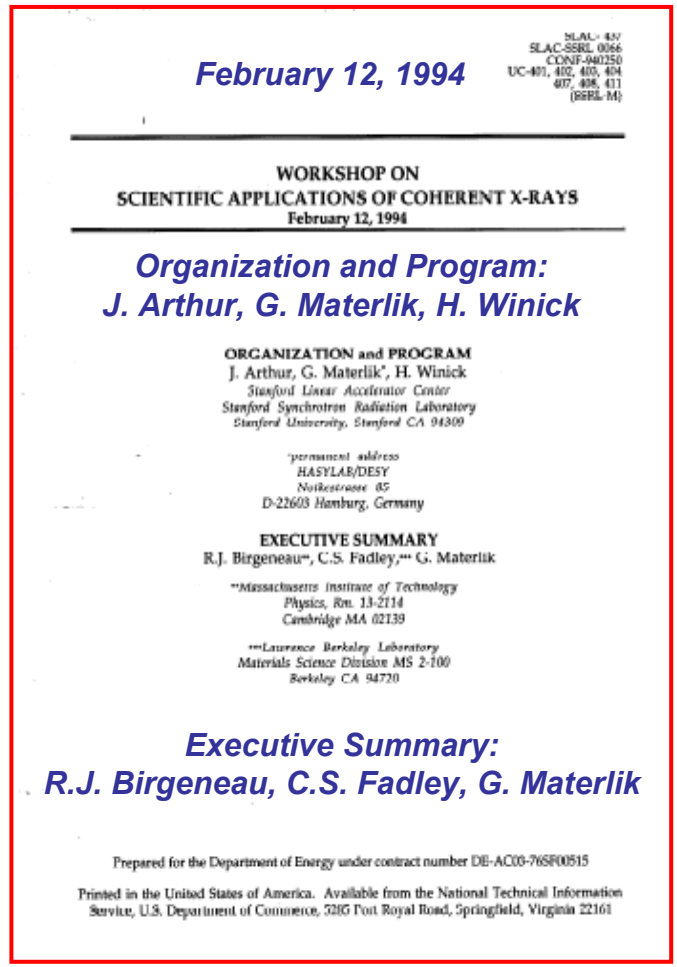
W. Spicer, J. Arthur, H. Winnick

Driving forces at DESY

Björn H. Wiik's vision for the future of DESY:

TESLA:
A linear e^+-e^- collider with integrated X-ray laser based on a super conducting linear accelerator

Build the TESLA Test Facility (TTF) at DESY



February 12, 1994

SLAC-PUB-6537
SLAC-SSRL-0066
CONF-940250
UC-401, 402, 403, 404
407, 408, 411
(SSRL-M)

WORKSHOP ON
SCIENTIFIC APPLICATIONS OF COHERENT X-RAYS
February 12, 1994

Organization and Program:
J. Arthur, G. Materlik, H. Winick

ORGANIZATION and PROGRAM
J. Arthur, G. Materlik*, H. Winick
Stanford Linear Accelerator Center
Stanford Synchrotron Radiation Laboratory
Stanford University, Stanford CA 94309

permanent address
HASYLAB/DESY
Notkestrasse 85
D-22603 Hamburg, Germany

EXECUTIVE SUMMARY
R.J. Birgeneau**, C.S. Fadley,*** G. Materlik

**Massachusetts Institute of Technology
Physics, Rm. 13-2114
Cambridge MA 02139

***Lawrence Berkeley Laboratory
Materials Science Division MS 2-100
Berkeley CA 94720

Executive Summary:
R.J. Birgeneau, C.S. Fadley, G. Materlik

Prepared for the Department of Energy under contract number DE-AC03-76SF00515

Printed in the United States of America. Available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

VUV FEL at TTF at DESY

Fall 1995:

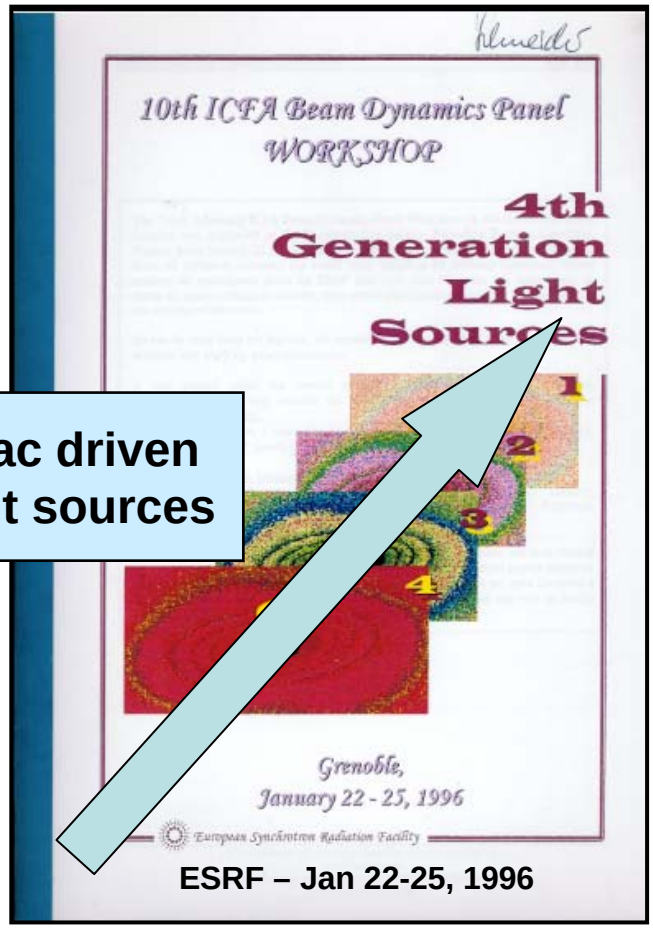
Approval for construction of the VUV FEL at TTF1 by DESY Council

2001, Sep 10: lasing at saturation at 98 nm
2001, Sep 11: first cluster experiment at TTF1

6 April 2006

Driving forces in the early stage

Scientific Workshops and Review Panels



ESRF – Jan 22-25, 1996

Linac driven light sources

US Department of Energy, BES

Panel on

Novel Coherent Light Sources

(Leone-Panel)

Gaithersburg, Maryland, USA
Jan 18-22, 1999

The panel found that the most exciting potential advance in the area of innovative science is most likely in the hard X-ray region, in the range of 8 to 20 keV, and even higher.

The panel unanimously recommends that the case for the science still must be improved.

The state-of-the-art light source facility of the future will include a complete marriage of accelerator principles and laser art, which has not previously been recognized widely.

Science and Science Politics

2000	German Science Council receives mandate from Federal Government to evaluate 8 large scale research facilities proposed by German Institutions
2000 Jun-Oct	EXPO 2000 exhibition "Light for the next Millenium" attracts 106 000 visitors
2001, Mar 23-24	TESLA Colloquium at DESY on Scientific Perspectives and Technical Realization of TESLA (~1000 participants)
2001, Sep 10	VUV FEL at TTF1 reaches saturation at 98 nm
2001, Sep 10/11	First successful cluster experiments by T. Möller et al.
2001, Oct	DESY site visit of the German Science Council working for the evaluation of the TESLA XFEL
2002, Jan-Feb	DESY exhibition Unter den Linden in Berlin (22 000 visitors)
2002, Nov 18	German Science Council recommends realization of the FEL project suggested by DESY and TESLA Collaboration
2002, Dec	Conclusion of first phase of TESLA Test Facility TTF1

Jochen R. Schneider
jochen.schneider@desy.de

Decisions for the European XFEL

2003, Feb 5 **Germany will pay 50% of the project cost which should be realized in European collaboration in Hamburg**

Committees in XFEL Preparation Phase

- ***International Steering Committee ISC (chair: H. Schunck BMBF)***

  First meeting 2004, Feb 2 **22** ***2009, Sep 2009 last meeting***

- ***Working Group on Scientific and Technical Issues STI (chair: F. Sette, ESRF)***

  First meeting 2004, Apr 1-2 **11** ***2007, Oct 10 last meeting***

- ***Working Group on Administrative and Funding Issues AFI (chair: H-F Wagner, BMBF)***

  First meeting 2004, Mar 19 **30** ***2009, Aug 25 last meeting***

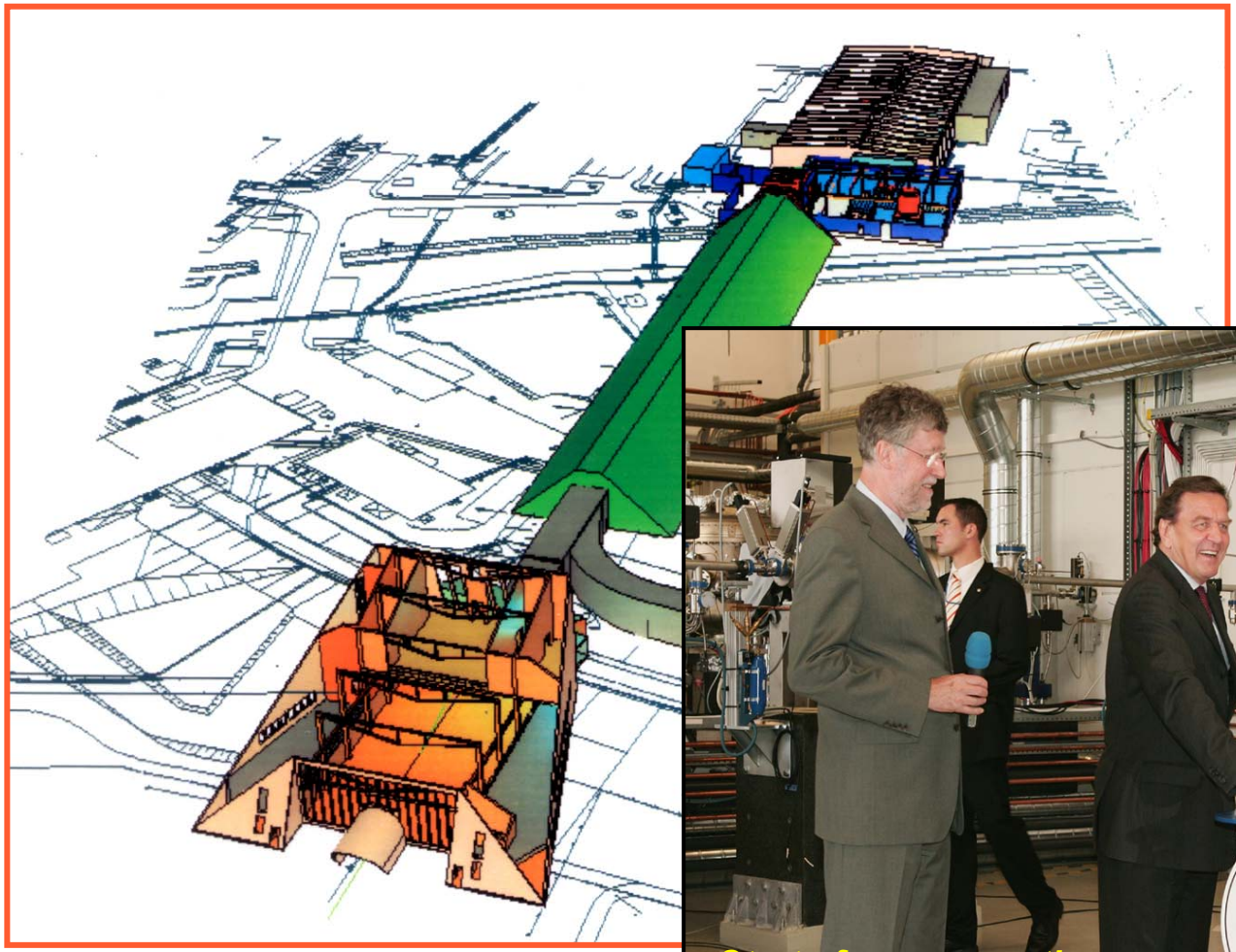
Jochen R. Schneider
jochen.schneider@desy.de

Success of FLASH helps to keep momentum

TTF1	2000, Feb 22	TTF1 demonstrates SASE at 108 nm
	2000, Oct 15	LEUTL at APS Argonne Nat. Lab. reaches saturation at 530 nm
	2001, Sep 10	TTF1 reaches SASE in saturation at 98 nm

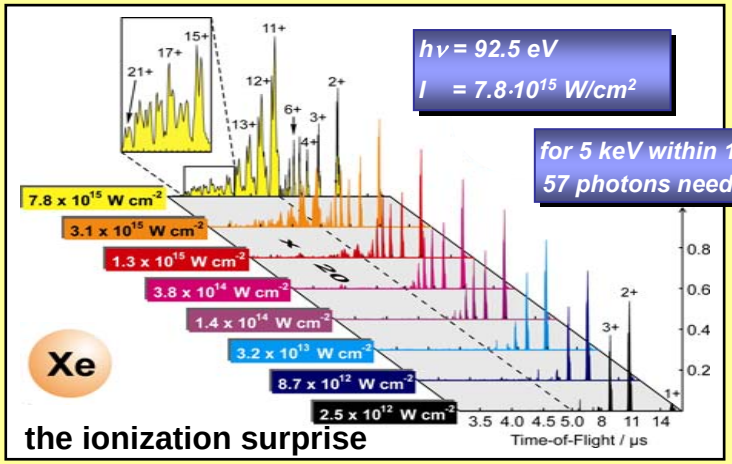
TTF2	2005, Jan 14	TTF2 reaches SASE in saturation at 33 nm
	2005, Jun 28	First observation of 2nd and 3rd harmonic at TTF2 at 19.9 and 10.6 nm, respectively
	2005, Nov 21	First lasing at TTF2 at 25.5 nm
FLASH	2006, Apr 27	FLASH reaches saturation at 13.1 nm
	2007, Oct	FLASH reaches lasing at saturation at 6.5 nm

The VUV-FEL user facility at DESY

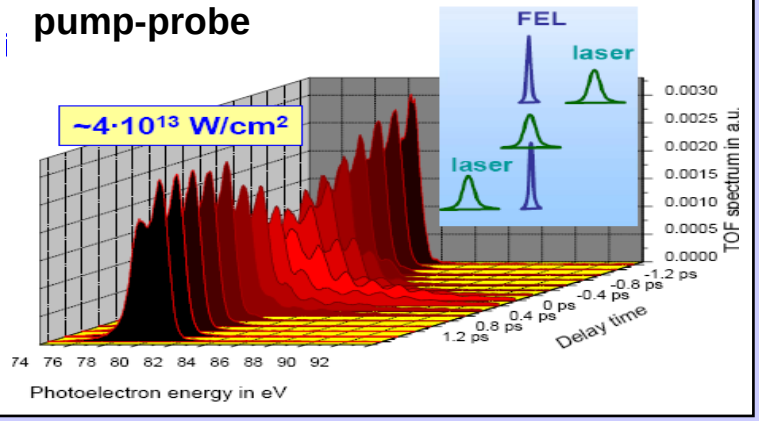


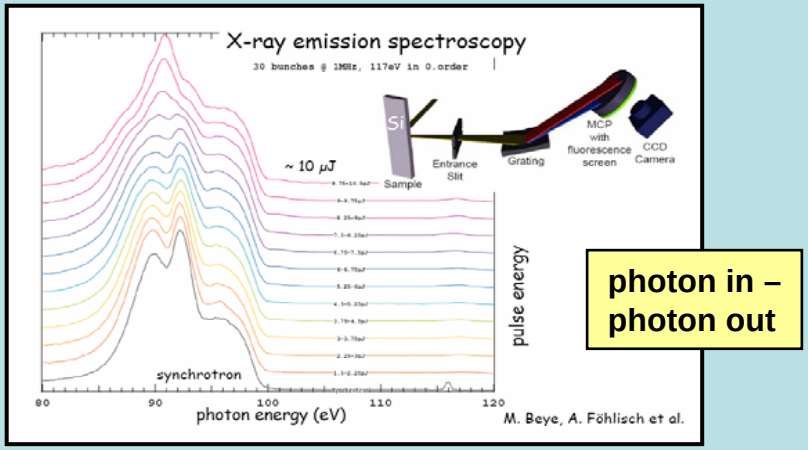
Start of user operation
3. August 2005

Success of FLASH helps to keep momentum

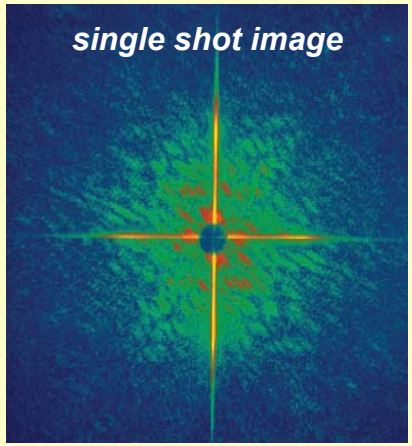


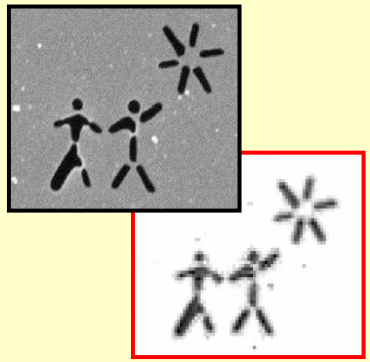
the ionization surprise





photon in – photon out

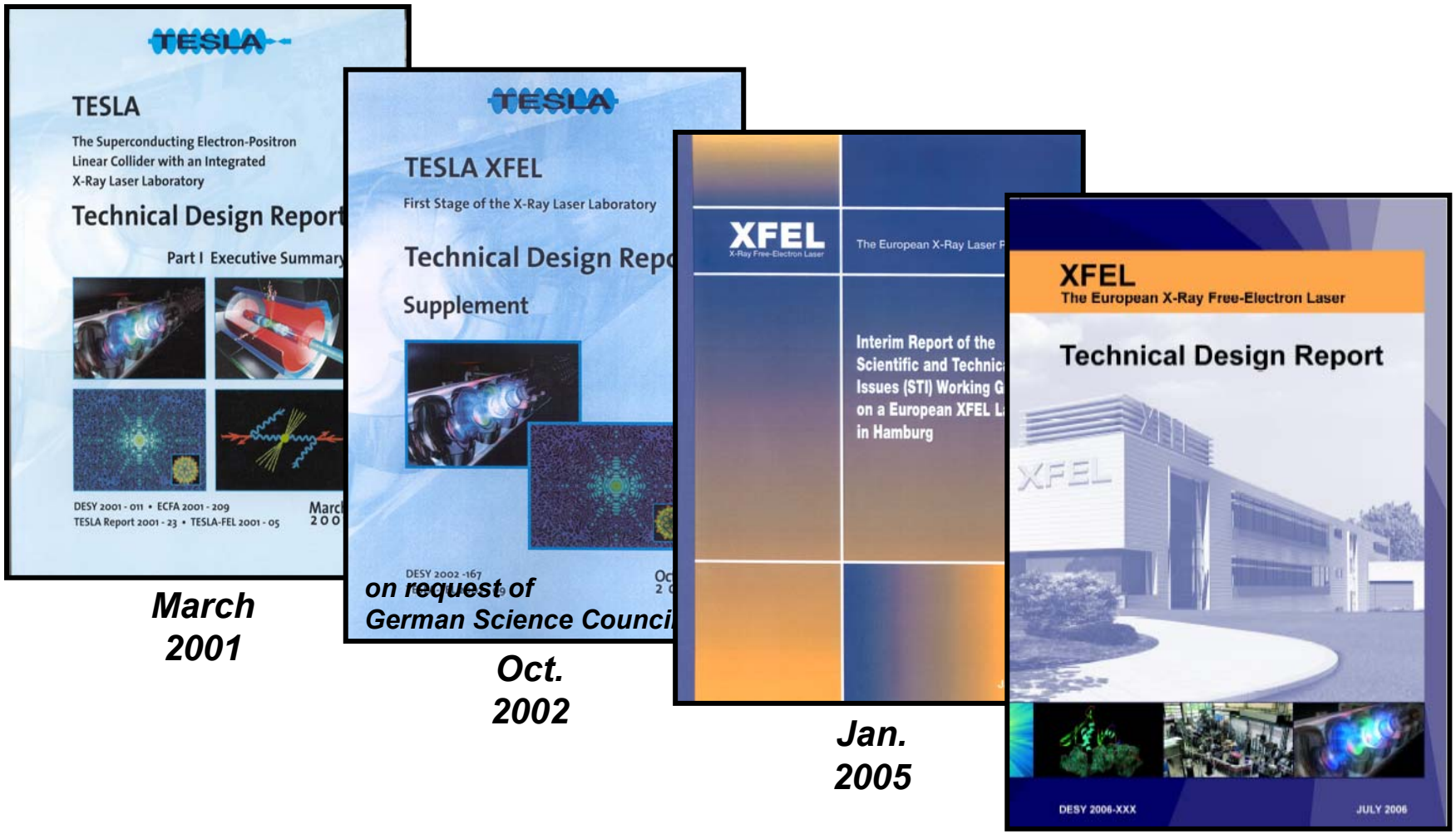




diffraction before destruction

Jochen R. Schneider
jochen.schneider@desy.de

Technical Design Reports



Jochen R. Schneider
jochen.schneider@desy.de

Technical Design Reports

2006, July 25: TDR for European XFEL handed over to STI

Launch of European XFEL Project

2007, June 5

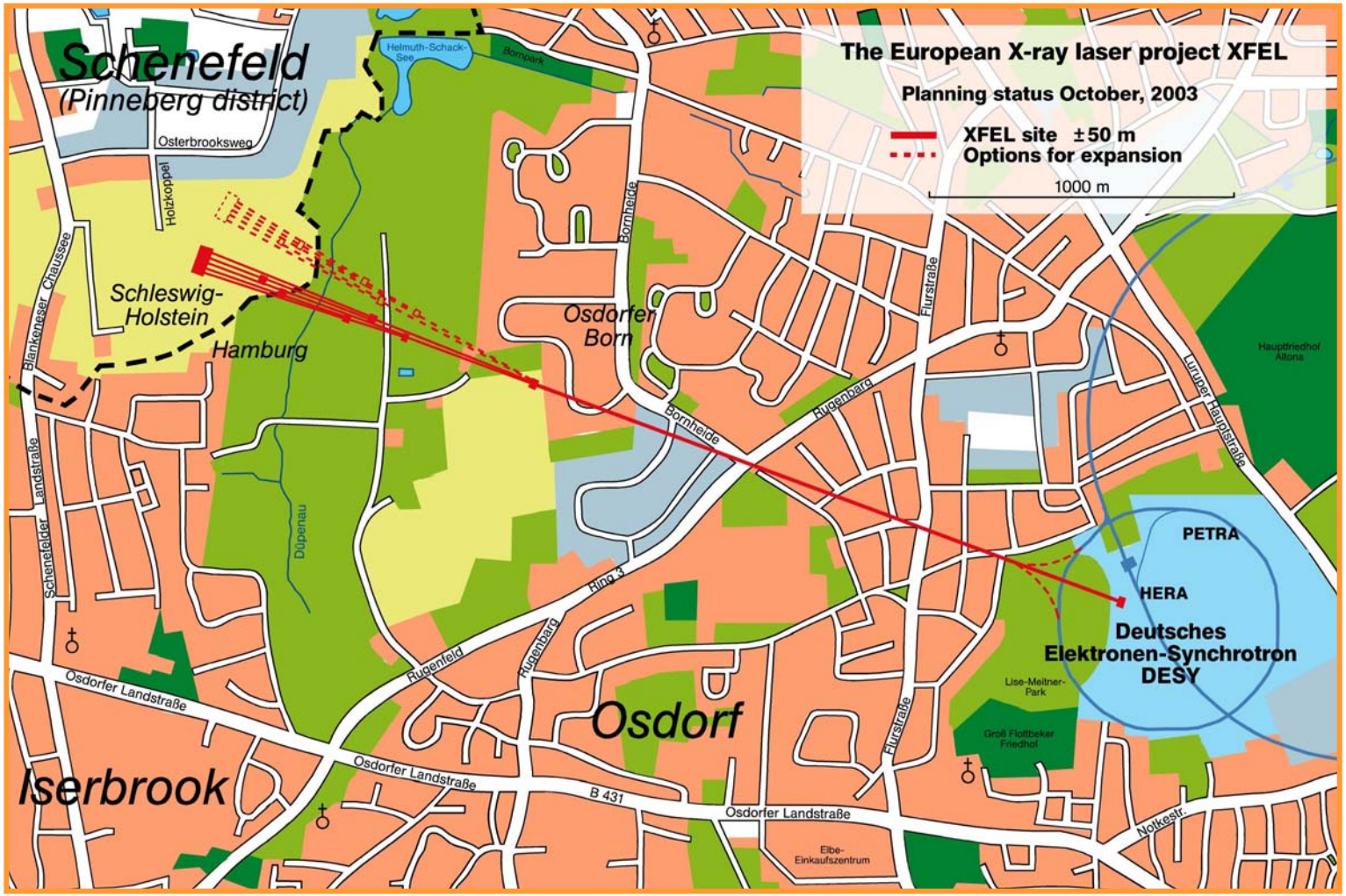
Realization as European Facility in 2 steps

1. step: 3 radiators with 6 experimental stations (850 M€ in 2005 prices)

2. step: Full facility (TDR) with 5 radiators and 10 experimental stations (construction cost 986 M€ in 2005 prices)

Jochen R. Schneider
jochen.schneider@desy.de

Plan approval procedure for the European XFEL

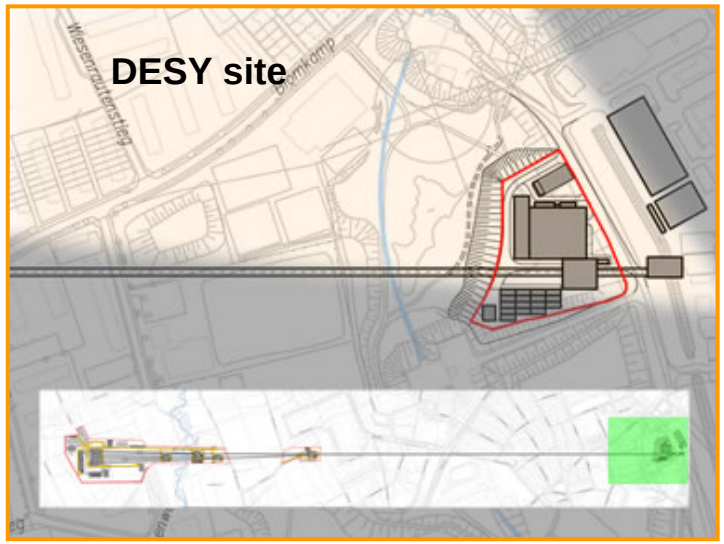


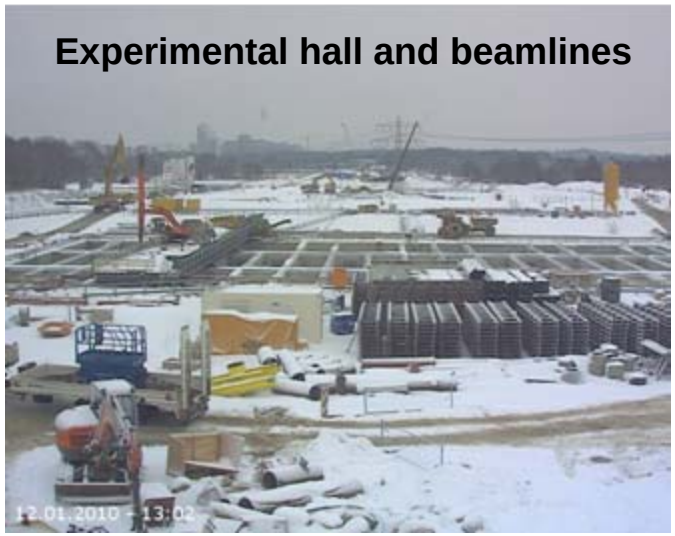
Jochen R. Schneider
jochen.schneider@desy.de

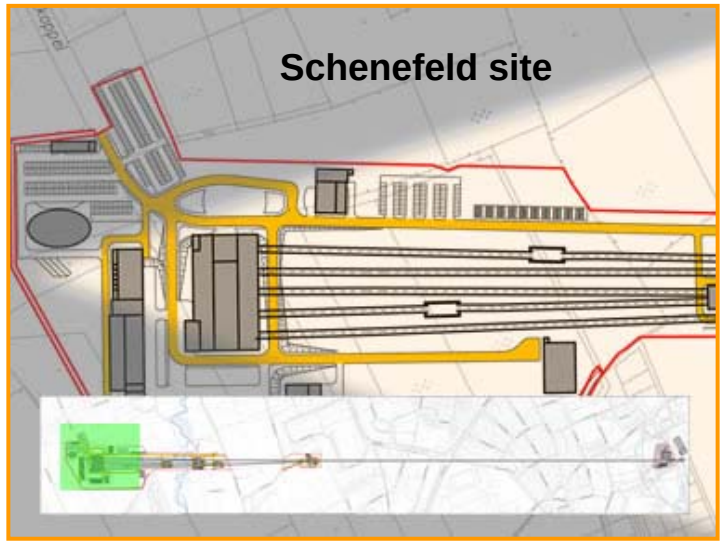
Plan approval procedure for the European XFEL

2005, April	Start of plan approval procedure
2005, Oct 25-26	Public hearing to discuss objections
2006, Jul 20	In conclusion of the plan approval procedure DESY receives the formal approval for its plan to construct and operate the European XFEL facility

XFEL Underground construction in full swing







European XFEL Convention – 2009, November 30

European XFEL Convention – 2009, November 30

Signing of the agreement between the Federal Republic of Germany and the Federal States of Hamburg and Schleswig-Holstein in the Hamburg town hall (30 Nov 2009)

Intergovernmental agreement between the Russian Federation and the Federal Republic of Germany on "Collaboration in the Development and Application of Accelerator Based Photon Sources" (15 Oct 2007)

Jochen R. Schneider
jochen.schneider@desy.de

UK withdraws participation in European XFEL

18 December 2009

"Science Board endorsed the recommendations of PALS (Physical and Life Science Committee) not to be involved in XFEL at the current time

and noted
that the UK had access to a Free Electron Laser through peer-reviewed access to LCLS in the US".

http://www.stfc.ac.uk/resources/pdf/SBNews161209.pdf

XFEL – an exciting story of solving problems

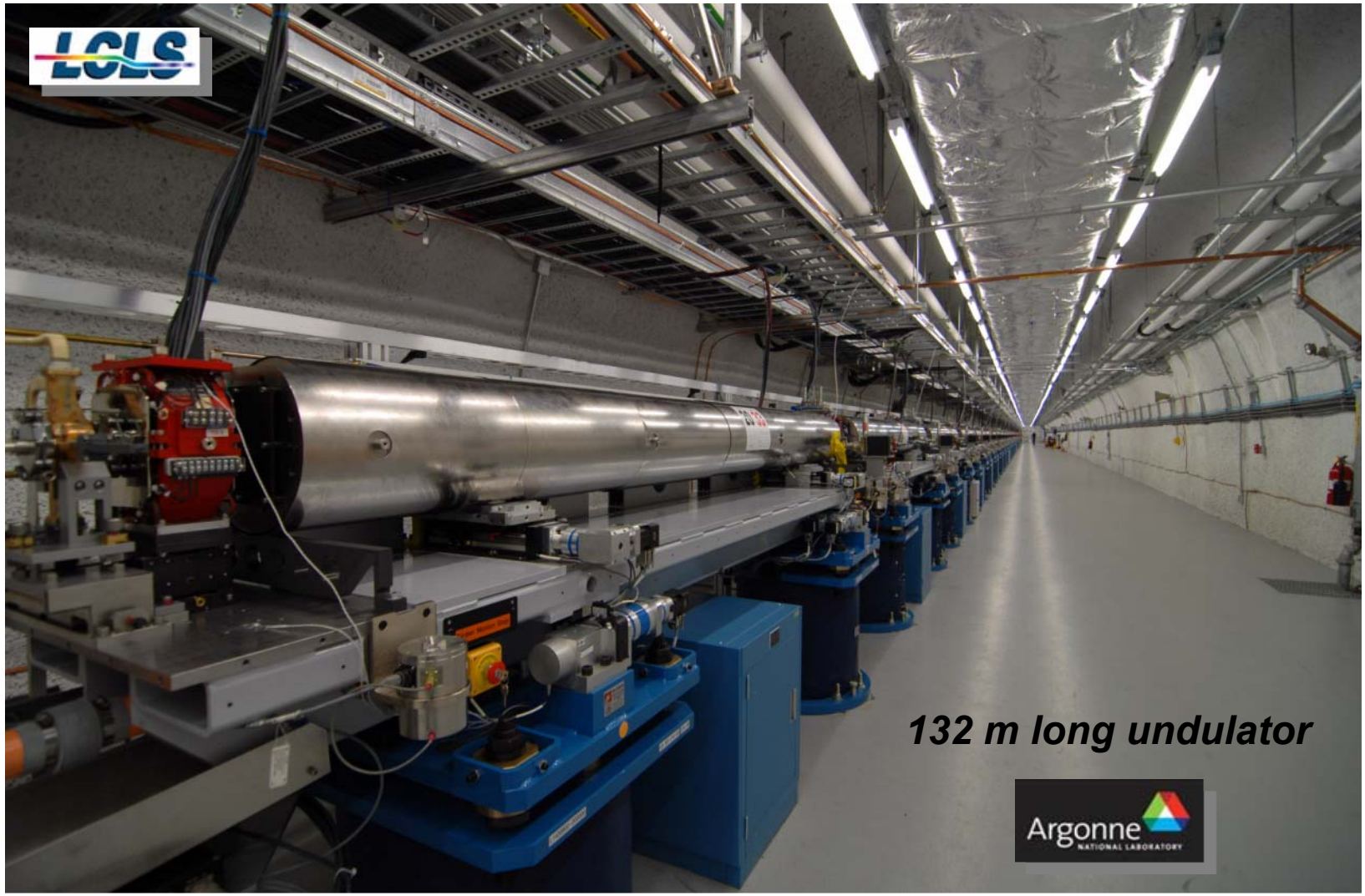
When talking about gains of 10 orders of magnitude you meet strong skepticism everywhere

ESFRI workshop on
Scientific challenges with XUV FELs
Daresbury – 2003, February 17-18

ESFRI-DESY workshop on
Challenges of the proposed European XFEL Laboratory
Hamburg – 2003, October 30-31

It all works for hard and soft X-rays !

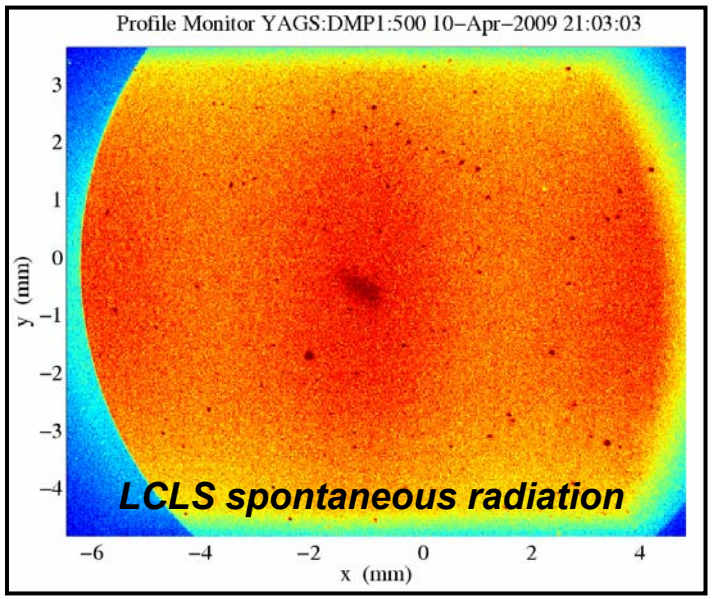
LCLS – the Linac Coherent Light Source at SLAC

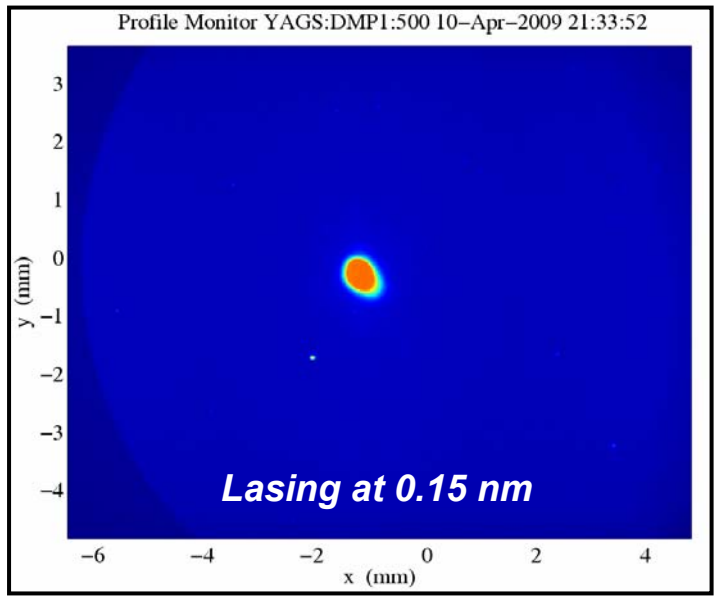


Jochen R. Schneider
jochen.schneider@desy.de

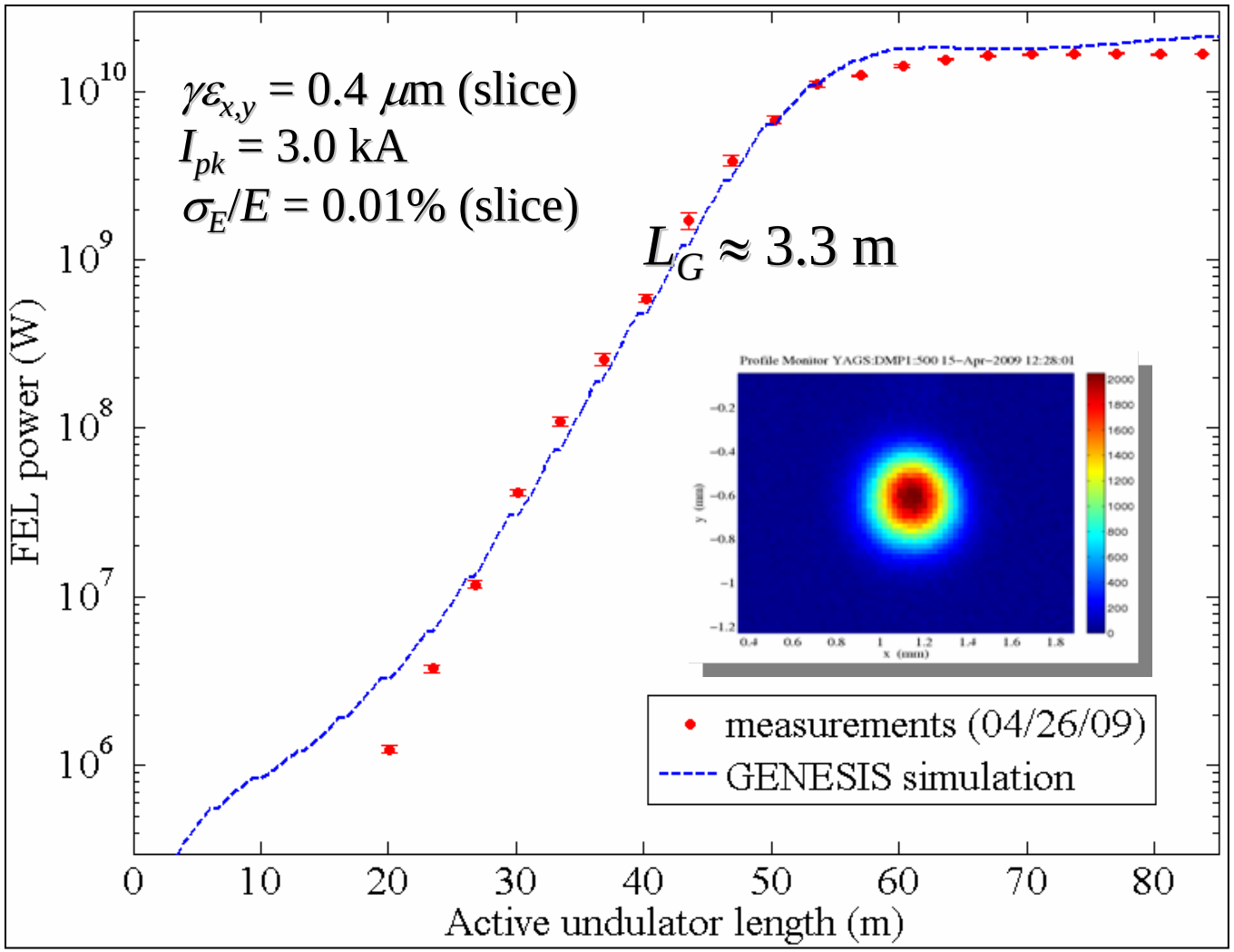
LCLS – the Linac Coherent Light Source at SLAC

10 April 2009





Gain length measurement at 0.15 nm



Jochen R. Schneider
jochen.schneider@desy.de

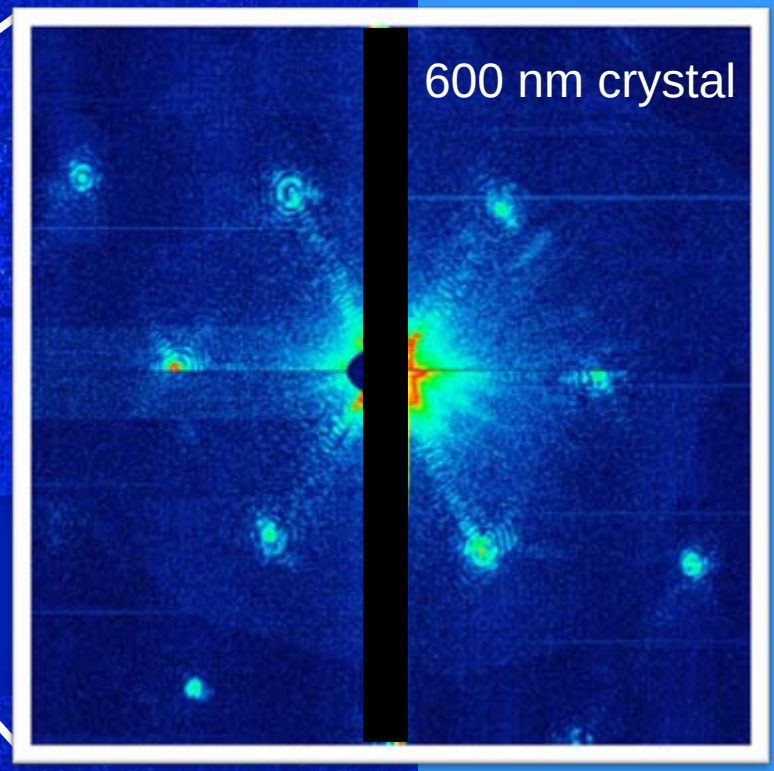
Single-pulse diffraction has been measured on pnCCDs from Photosystem I nanocrystals at LCLS

Photosystem I nanocrystals flowing in water jet.

Pulse duration: 80 fs

Patterns collected at 30 Hz

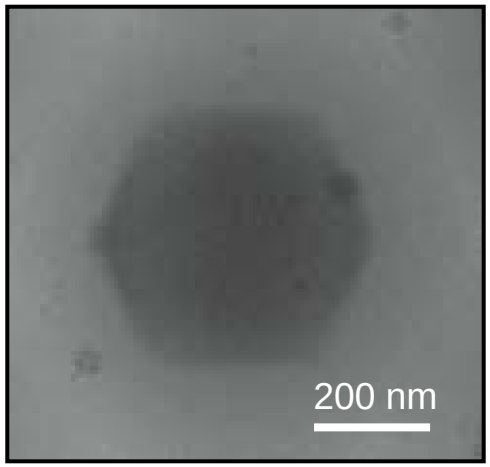
5 Tbyte data in one night!

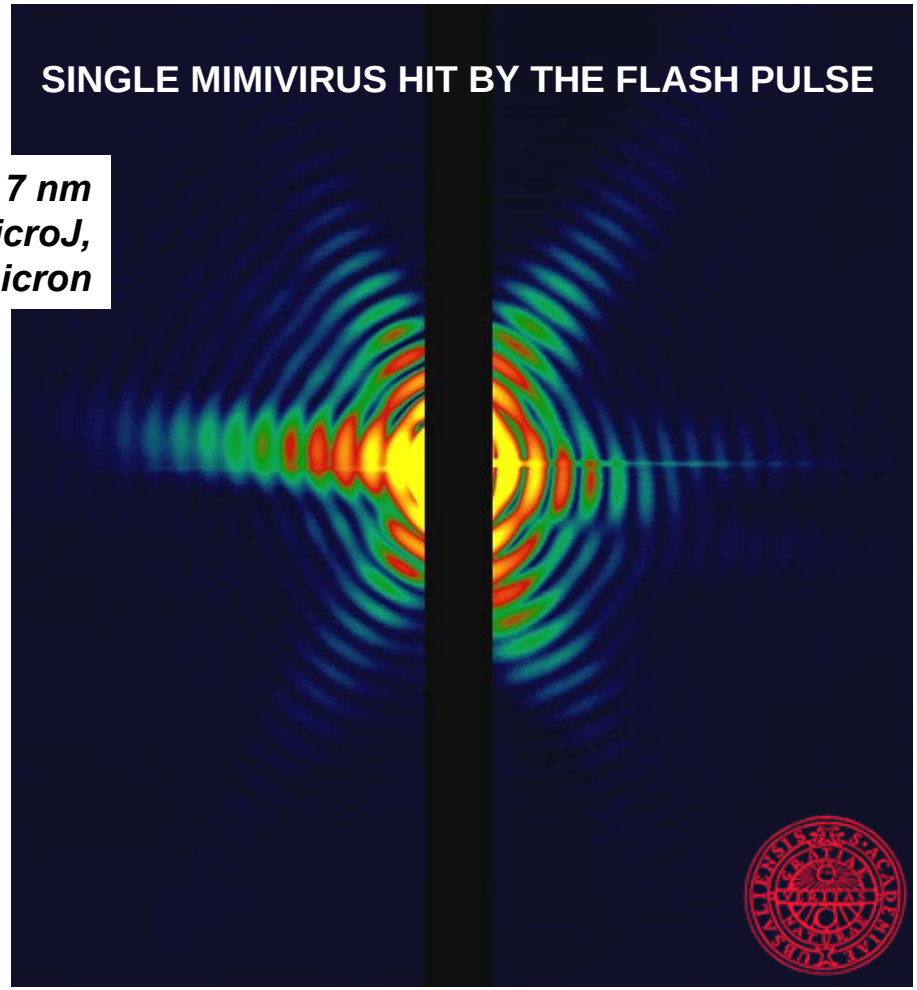


Spokesperson: Henry Chapman
for collaboration of
Center for Free Electron Laser Science DESY,
Arizona State University,
Max Planck Institute for Medical Research,
Max Planck Advanced Study Group at CFEL,
PULSE Institute, SLAC, LLNL, Uppsala University

Single Particle Imaging

Mimivirus





Wavelength: 7 nm
flux: ~ 20 microJ,
focused to ~ 20 micron

Work in progress!

Uppsala: J. Hajdu (PI), M. Svenda, F. R. N. C. Maia, T. Ekeberg, M. Seibert, J. Andreasson, D. Odić, B. Iwan, A. Rocker, O. Jönsson, D. Westphal

Marseille: J-M. Claverie, Ch. Abergel, V. Tichanné-Seltzer

Hamburg: H. N. Chapman, A. Barty, J. Schulz, L. Gumprecht, N. Coppola, D. P. DePonte, A. Aquila, M. Liang, A. Martin

SASE Free-Electron Lasers are discovery machines

with great potential for performance improvements

The European XFEL will be unique in combining the extreme peak brilliance characteristic for FELs with a very high average brilliance

Thank you

Thanks for input are due to

H.N. Chapman, P. Folkerts, J. Galayda, J. Hajdu, G.Materlik, J. Rossbach, T. Tschentscher, K. Witte

Thanks to funding agencies and the people working for them

Jochen R. Schneider
jochen.schneider@desy.de