The European XFEL

S. Simrock
DESY, Hamburg, Germany

Lecture Schedule (March 2008)

- LLRF Part I (Requirements and Design)
  - March 6, 13:30
- LLRF Part 2 (Maschine Studies at FLASH)
  - March 7: 10:00
- LLRF Part 3 (LLRF for the XFEL)
  - March 11 at 13:30
- Timing and Sync. Part I (Concepts)
  - March 14 at 10:00
- Timing and Sync. Part II (Design)
  - March 17 at 10:00
- **<u>European XFEL (Project Overview)</u>**
  - **<u>March 26 at 10:00</u>**

Outline XFEL

- Motivation
- FLASH as user facility
  - Experiments
  - Design
  - Performance
  - Future Plans
- European XFEL
  - Project
  - Design
  - Schedule
  - Organisation

Outline XFEL (C‘tnd)

- XFEL Consortium
- Status of in-kind-contributions
- Installation Workflow
- Configuration Management
- Availability Analysis
- Risk Register

FLASH

FLASH and XFEL
Time to explore the femtosecond dynamics of nature

- *Ever seen the machinery of a living cell at work at atomic resolution?*
- *Observed how molecules change shape in femtoseconds during chemical or biochemical reactions?*
- *Watched a drug molecule enter a protein receptor in real time?*

Soon X-ray free-electron lasers will enable us to probe ultra fast physical, chemical and biochemical processes at atomic resolution, opening new frontiers for science and technology.
At long last we may see, and not just model, how molecular machines really work.

See more: FLASH booklet, published in June 2007

http://flash.desy.de/

FLASH.

The Free-Electron Laser
in Hamburg

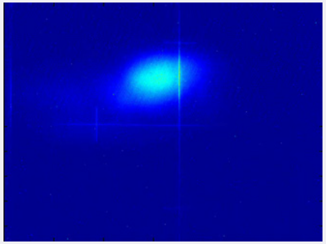
New technologies for new science: Soon X-ray free-electron lasers will enable us to probe ultrafast physical, chemical and biochemical processes at atomic resolution, opening new frontiers for science and technology. At long last we may see, and not just model, how molecular machines really work.

Accelerators | Photon Science | Particle Physics

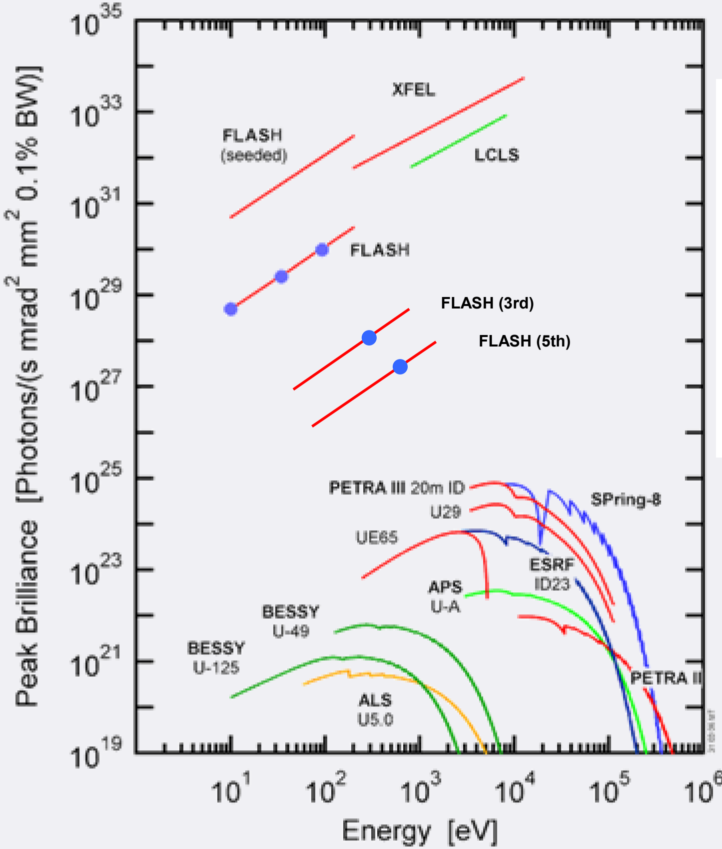
Deutsches Elektronen-Synchrotron
Member of the Helmholtz Association

This is, where we are…

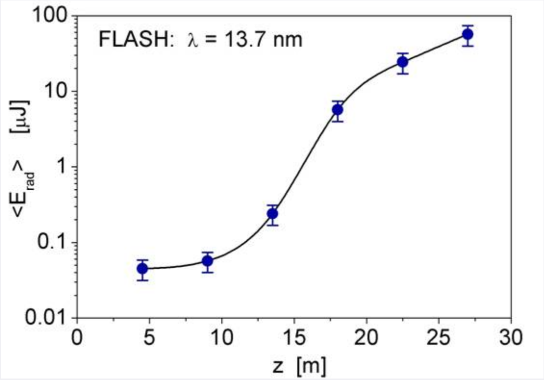
April 26, 2006

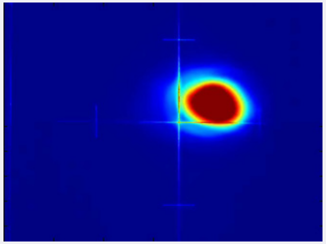


<>E<> = 5 µJ



Recent User run 2006 / 2007



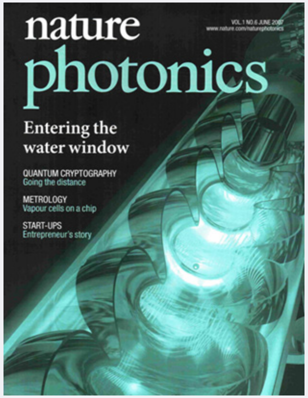


<E> = 70 µJ

… the actual reference…

Operation of a free-electron laser from the extreme ultraviolet to the water window

W. ACKERMANN[1], G. ASOVA[2], V. AYVAZYAN[3], A. AZIMA[3], N. BABOI[3], J. BÄHR[2], V. BALANDIN[3], B. BEUTNER[4], A. BRANDT[3], A. BOLZMANN[5], R. BRINKMANN[3], O. I. BROVKO[6], M. CASTELLANO[7], P. CASTRO[3], L. CATANI[8], E. CHIADRONI[8], S. CHOROBA[3], A. CIANCHI[8], J. T. COSTELLO[9], D. CUBAYNES[10], J. DARDIS[9], W. DECKING[3], H. DELSIM-HASHEMI[4], A. DELSERIEYS[11], G. DI PIRRO[7], M. DOHLUS[3], S. DÜSTERER[3], A. ECKHARDT[4], H. T. EDWARDS[12], B. FAATZ[3], J. FELDHAUS[3], K. FLÖTTMANN[3], J. FRISCH[13], L. FRÖHLICH[4], T. GARVEY[14], U. GENSCH[2], CH. GERTH[3], M. GÖRLER[3], N. GOLUBEVA[3], H.-J. GRABOSCH[2], M. GRECKI[15], O. GRIMM[3], K. HACKER[3,4], U. HAHN[3], J. H. HAN[3], K. HONKAVAARA[4], T. HOTT[3], M. HÜNING[3], Y. IVANISENKO[16], E. JAESCHKE[17], W. JALMUZNA[18], T. JEZYNSKI[15], R. KAMMERING[3], V. KATALEV[3], K. KAVANAGH[9], E. T. KENNEDY[9], S. KHODYACHYKH[2], K. KLOSE[2], V. KOCHARYAN[3], M. KÖRFER[3], M. KOLLEWE[3], W. KOPREK[18], S. KOREPANOV[2], D. KOSTIN[3], M. KRASSILNIKOV[2], G. KUBE[3], M. KUHLMANN[3], C. L. S. LEWIS[11], L. LILJE[3], T. LIMBERG[3], D. LIPKA[3], F. LÖHL[4], H. LUNA[9], M. LUONG[19], M. MARTINS[4], M. MEYER[10], P. MICHELATO[20], V. MILTCHEV[4], W. D. MÖLLER[3], L. MONACO[20], W. F. O. MÜLLER[1], O. NAPIERALSKI[15], O. NAPOLY[19], P. NICOLOSI[21], D. NÖLLE[3], T. NUÑEZ[3], A. OPPELT[2], C. PAGANI[20], R. PAPARELLA[19], N. PCHALEK[3,4], J. PEDREGOSA-GUTIERREZ[9], B. PETERSEN[3], B. PETROSYAN[2], G. PETROSYAN[3], L. PETROSYAN[3], J. PFLÜGER[3], E. PLÖNJES[3], L. POLETTO[2], K. POZNIAK[18], E. PRAT[3,4], D. PROCH[3], P. PUCYK[18], P. RADCLIFFE[3], H. REDLIN[3], K. REHLICH[3], M. RICHTER[22], M. ROEHRS[3,4], J. ROENSCH[4], R. ROMANIUK[18], M. ROSS[13], J. ROSSBACH[4], V. RYBNIKOV[3], M. SACHWITZ[2], E. L. SALDIN[3], W. SANDNER[23], H. SCHLARB[3], B. SCHMIDT[3], M. SCHMITZ[3], P. SCHMÜSER[4], J. R. SCHNEIDER[3], E. A. SCHNEIDMILLER[3], S. SCHNEPP[1], S. SCHREIBER[3], M. SEIDEL[3,24], D. SERTORE[20], A. V. SHABUNOV[6], C. SIMON[19], S. SIMROCK[3], E. SOMBROWSKI[3], A. A. SOROKIN[25,22], P. SPANKNEBEL[26], R. SPESYVTSEV[16], L. STAYKOV[2], B. STEFFEN[3], F. STEPHAN[2], F. STULLE[3], H. THOM[3], K. TIEDTKE[3], M. TISCHER[3], S. TOLEIKIS[3], R. TREUSCH[3], D. TRINES[3], I. TSAKOV[27], E. VOGEL[3], T. WEILAND[1], H. WEISE[3], M. WELLHÖFER[4], M. WENDT[3,12], I. WILL[23], A. WINTER[3], K. WITTENBURG[3], W. WURTH[4], P. YEATES[9], M. V. YURKOV[3]*, I. ZAGORODNOV[3] AND K. ZAPFE[3]



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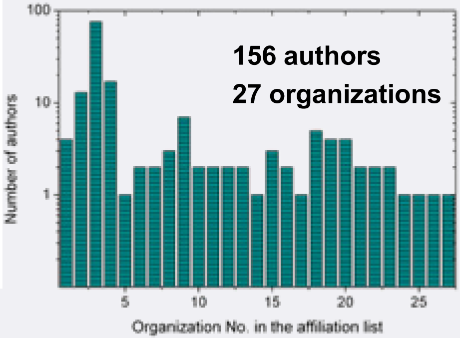
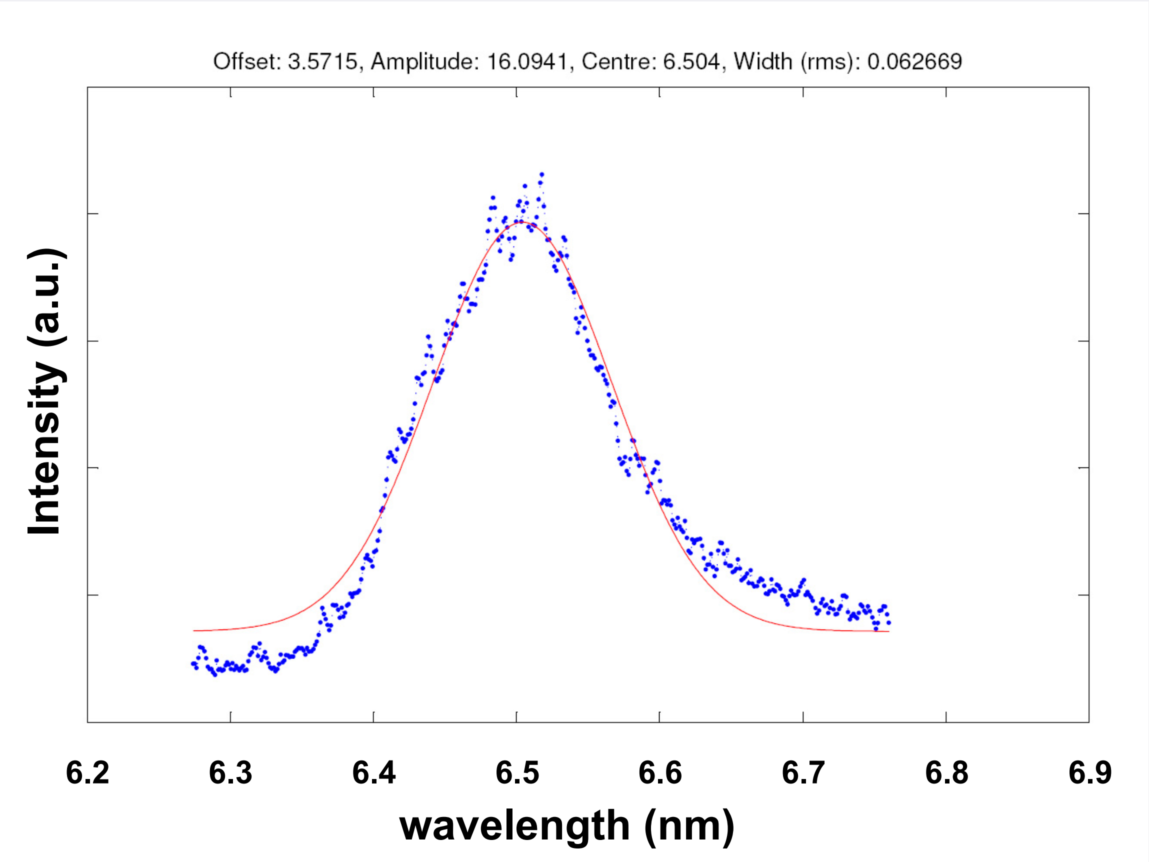


… and lasing at 6.5 nm …



… and the best:

- first lasing at 80 nm (TTF1) took months
- first lasing at 6.9 nm instead of the previously reached 13 nm took hours

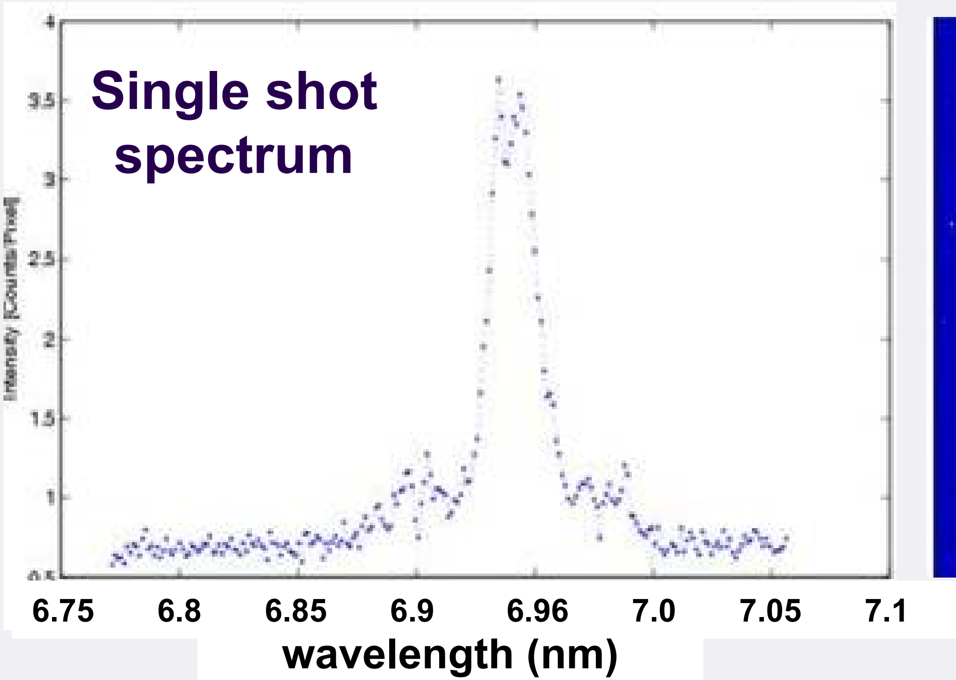
This demonstrates the scalability of the concept towards the XFEL.

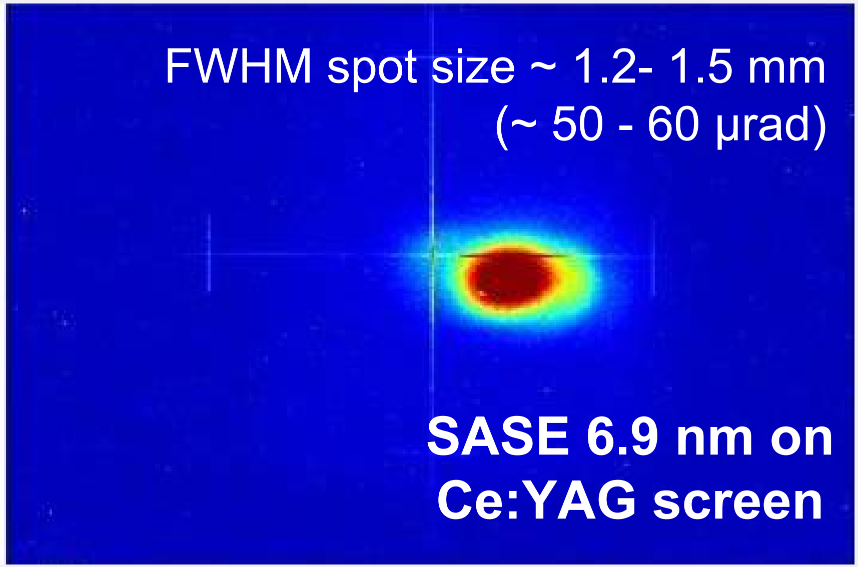
… preliminary FLASH radiation properties …

Lasing could be demonstrated at 6.5 nm and 6.9 nm;
(already now, 7 nm requested by users)

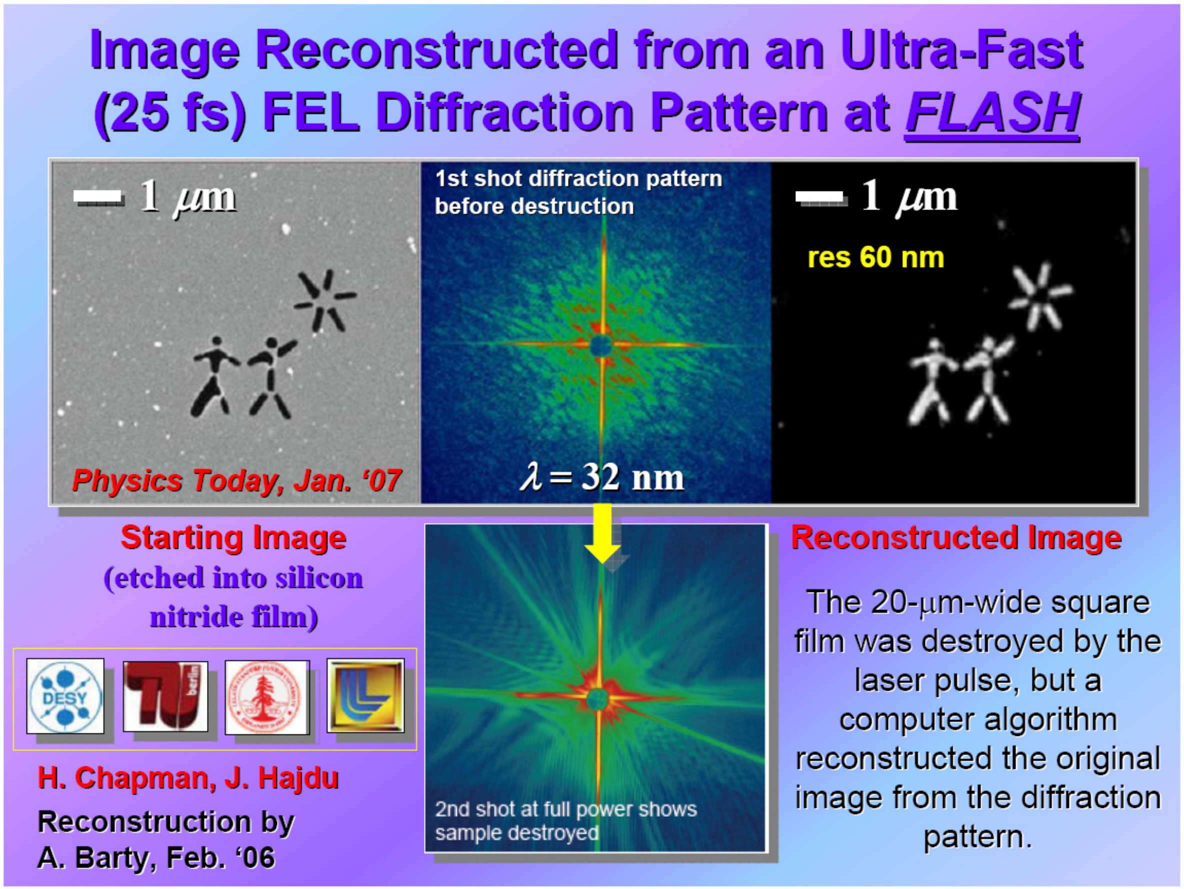
Estimate: 2 µJ level (±50%)

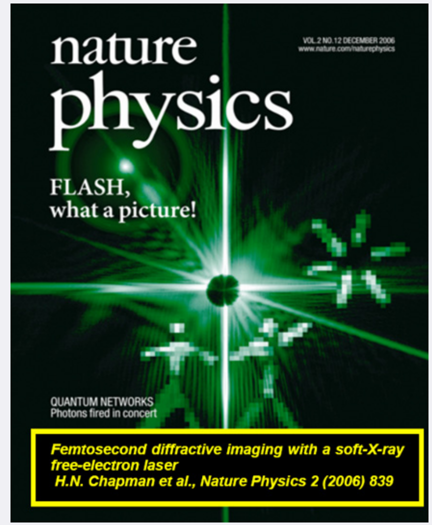
the single shot spectra show a small number of modes → preliminary estim. pulse length: in the 5 fs range (rough extrapolation from the 13 nm)





… this, how others see FLASH …

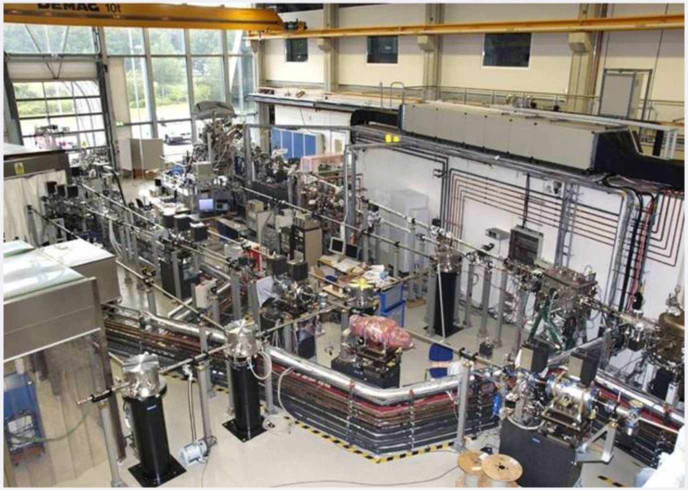




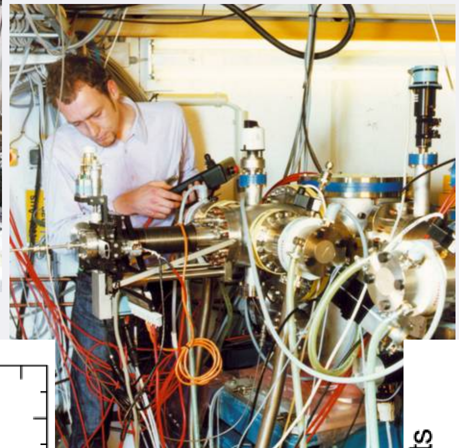
nature physics,
December 2006

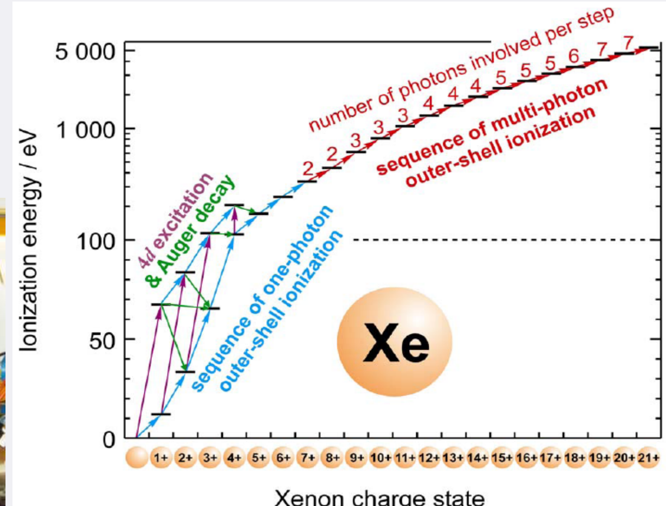
Paul Emma: The LCLS Project at SLAC
Fermilab Colloquium, January 31, 2007

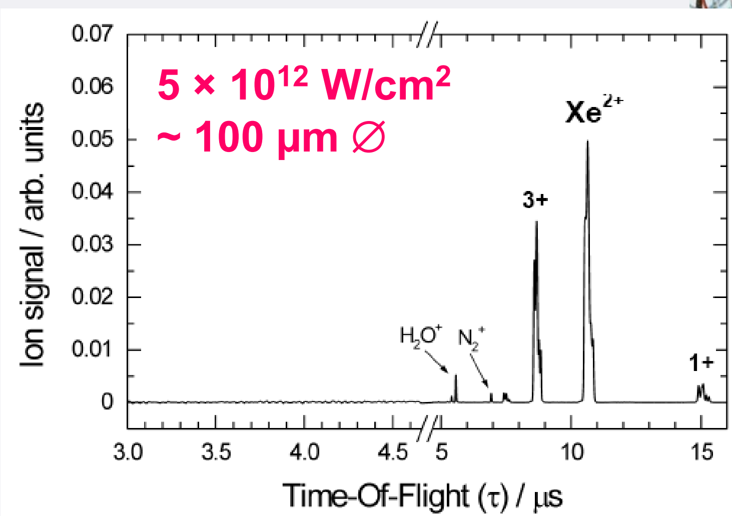
… and this, how we experience FLASH …

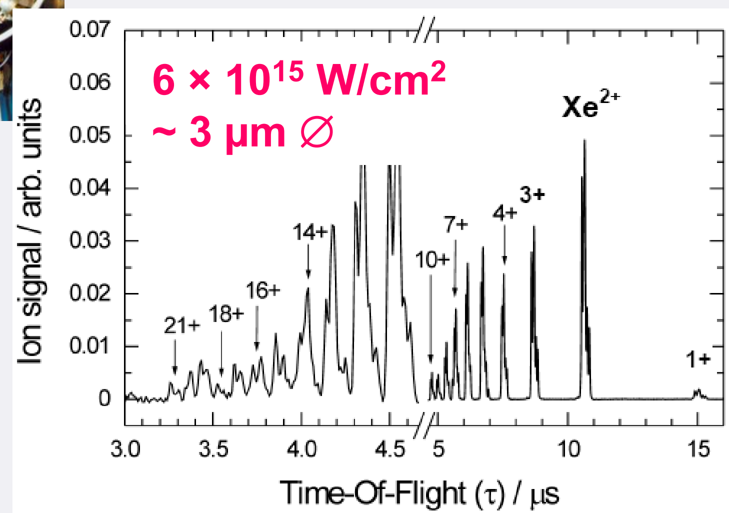


T. Feigl (IOF), M. Richter, A.A. Sorokin (PTB), K. Tiedtke, H. Wabnitz (DESY): FLASH, September 2006



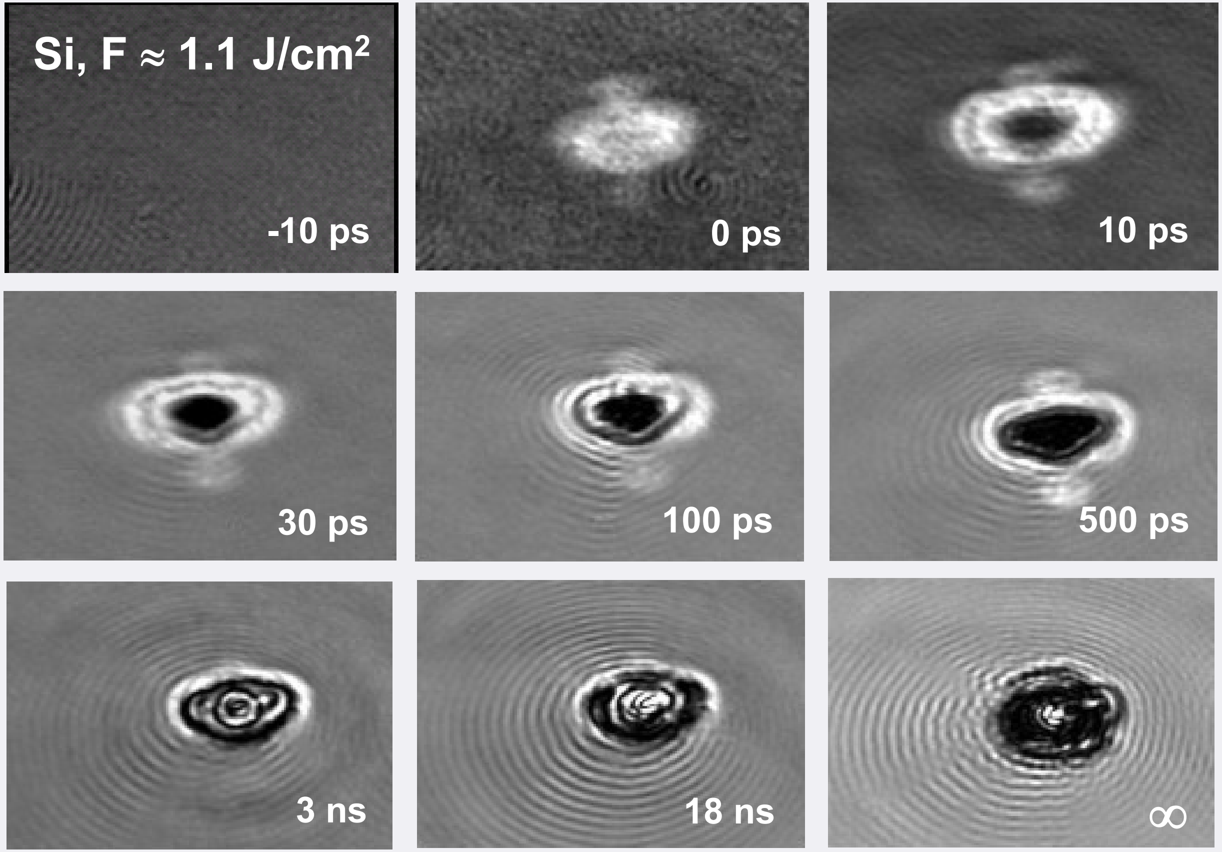






… and this, how we „destroy“ using FLASH

K. Sokolowski-Tinten et al. **Fast melting of silicon**



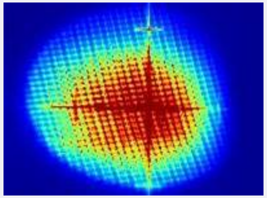
Time-resolved snapshots of a bulk silicon sample after excitation with a single FEL pulse at a fluence of 1.1 J/cm^2.

Pictures taken with the help of a probe laser.

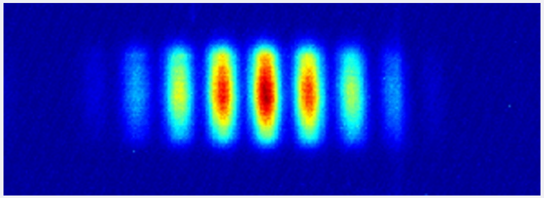
The FLASH Photon Beam

e.g. 25.5 nm wavelength

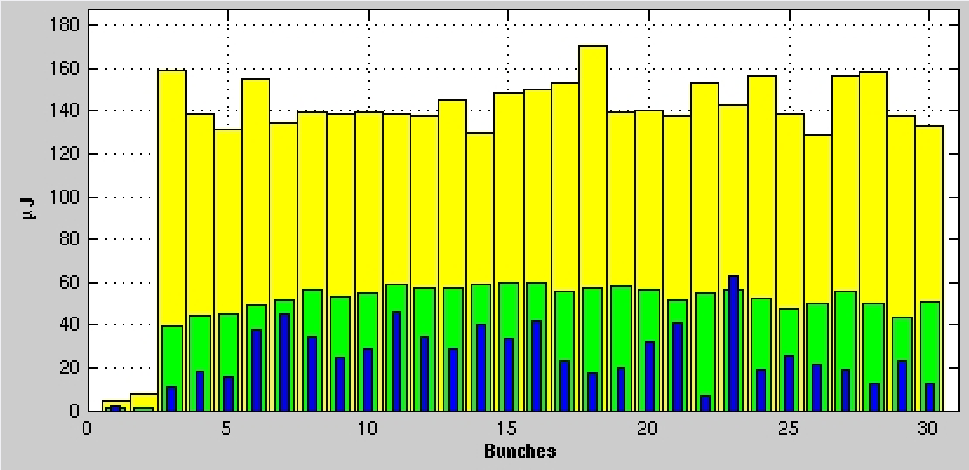
spot size



double slit diffraction pattern



3 mm spot size (FWHM) @ 18.5 m distance
angular divergence 160 µrad
→ high degree of coherence



Wavelength (fundamental)	**47 – 6.5**	**nm**	**(tunable!!!)**
FEL range (harmonics)	**→ 2.7**	**nm**	
Average energy per pulse	up to 100	µJ	
Maximum energy per pulse	200	µJ	
Radiation pulse duration	10 – 50	fs	
Peak power (calc. from average)	~ 3 – 4	GW	
Spectral width (FWHM)	**0.5 – 1**	**%**	
Angular divergence (FWHM)	160	µrad	
Peak brilliance (calc. from max)	**5-10×10^{29}**	ph/s/mrad^2/mm^2/(0.1% bw)	

Multibunch SASE signal (µJ) recorded with MCP Detector

max
average
single

Second Round of User Experiments at FLASH

45 proposals submitted in 2006
32 proposals approved in Dec 2006
Beamtime: Oct 2006 - ~Dec 2008

Proposal no	Proposer, Project Leader	Title
II-20060122	Jose Ramon Crespo Lopez-Urrutia	Resonant single- and multi-photon excitation and photoionization of highly charged ions by FEL radiation
II-20060250	Robert Moshammer	Few Photon Multiple Ionization of Atoms and Molecules using a Reaction Microcope
II-20060251	Robert Moshammer	Coulomb-Explosion Imaging of Small Molecules and Pump-Probe Experiments
II-20060259	Reinhard Dörner	Multiple Fragmentation Processes of Molecules and Clusters Probed by Momentum Imaging Spectroscopy
II-20060262	Alexander Dorn	A Lithium Magneto Optical Trap in a Reaction Microscope at FLASH: I. Complete Photo-Fragmentation of Lithium Atoms II. Dynamics of a Strongly Coupled Ultra Cold Plasma
I-20060263	Uwe Hergenhahn	Intermolecular Coulombic decay in doped water clusters
II-20060278 EC	Marc Vrakking	Velocity map imaging of strong field processes
I-20060280 EC	Michael Meyer, John Costello	Two-color photoionization of atoms and molecules
I-20060293	Axel Reinköster, Uwe Becker	Study of multiphoton-ionization processes of free atoms and molecules
I-20060297	Nora Berrah	High field studies of negative and positive ions at FLASH
II-20060277	Karl-Heinz Meiwes-Broer	Electron Structure and Dynamics in Clusters
II-20060286	Thomas Möller	Ultrafast processes and imaging of clusters
II-20060257	Ivan Vartaniants, Christian Gutt	Characterization and Coherent Scattering Applications of the Femtosecond Pulses at the FLASH Facility
II-20060289	Axel Rosenhahn	Single pulse digital in-line holography with VUV radiation and soft X-rays at FLASH
II-20060264	Stefan Eisebitt	Time Resolved Imaging and Scattering for the Study of Sub-Picosecond Correlations on Nanometer Lengthscales
II-20060270	Henry Chapman	Flash Diffraction Imaging of Biological Samples
II-20060296	Simone Techert	Probing the molecular dynamics of supramolecular assemblies by time-resolved x-ray diffraction in the low q regime
II-20060253	Klaus Sokolowski-Tinten	Transient response of solids to high intensity femtosecond XUV-excitation
II-20060267 EC	David Riley	Probing plasma dynamics using time-resolved spectroscopy
II-20060271	Art Nelson	Creation and characterization of WDM using high intensity XUV radiation
II-20060279 EC	Arne Höll, Gianluca Gregori	Thomson scattering measurements of plasma dynamics
II-20060283 EC	Janos Hajdu, N. Timneanu	X-ray induced Coulomb explosions and nuclear fusion
I-20060254 EC	Andrea Cavalleri	Resonant Soft X-ray Scattering in Complex Oxides with near-2-nm Free Electron Laser Pulses
II-20060258	Kai Rossnagel	Femtosecond Dynamics of Photoinduced Insulator-to-Metal Transitions in Layered Transition-Metal Compounds Probed by Time- and Momentum-Resolved Photoemission
I-20060269	Marco Rutkowski, Helmut Zacharias	Investigation of highly excited surface reactions
II-20060276	Alexander Föhlisch	Non-equilibrium dynamics and low energy excitations in complex systems
II-20060285	Hermann Dürr	Femtosecond electron and spin dynamics in functional materials
II-20060108	Michael Martins	Multi-photon processes in soft X-ray regime
II-20060292	Mathias Richter	Quantitative gas-phase experiments for FEL photon diagnostics at high photon energies and smal spot size
II-20060261	Lutz Kipp	VUV-FEL Nanospectroscopy
I-20060266	Marco Rutkowski, Helmut Zacharias	Evaluation of FEL pulse duration by non-linear autocorrelation in atoms and molecules
II-20060268	Michael Rübhausen	Light Scattering at the FEL
II-20060272	Markus Drescher	Pump-probe experiments exploiting FLASH's intrinsic temporal resolution

Collab. (II-20060250 – II-20060278 EC)
Collab. (II-20060257 – II-20060264)
Collab. (II-20060108 – II-20060292)

Gas phase (atoms, molecules, ions)

Clusters

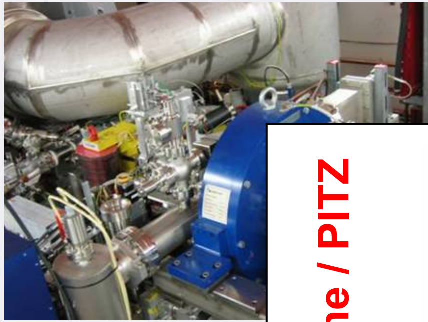
Imaging, diffraction

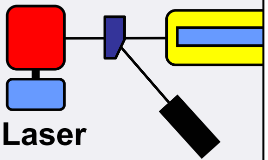
Warm dense matter

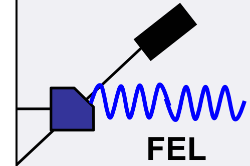
Solids, surfaces

Technical developments

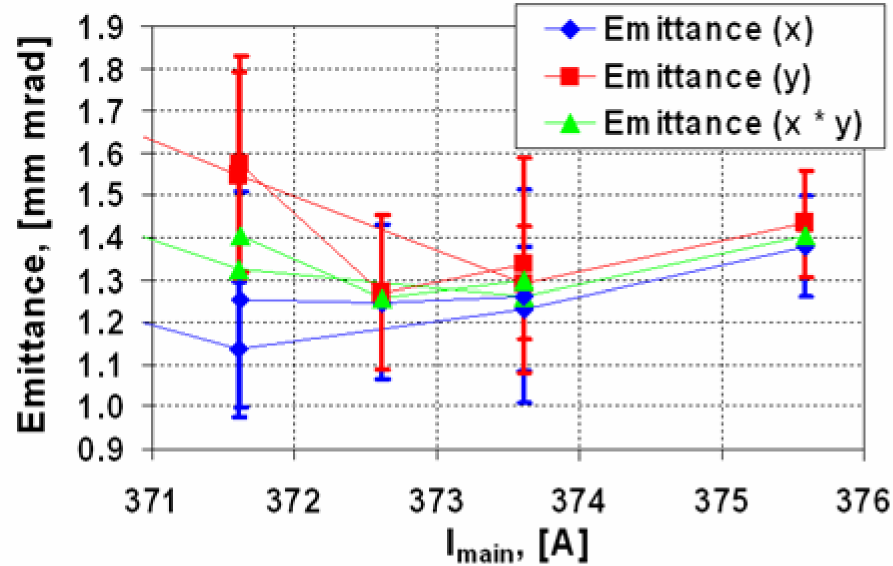
FLASH Facility







Recently reached at DESY-Zeuthe / PITZ



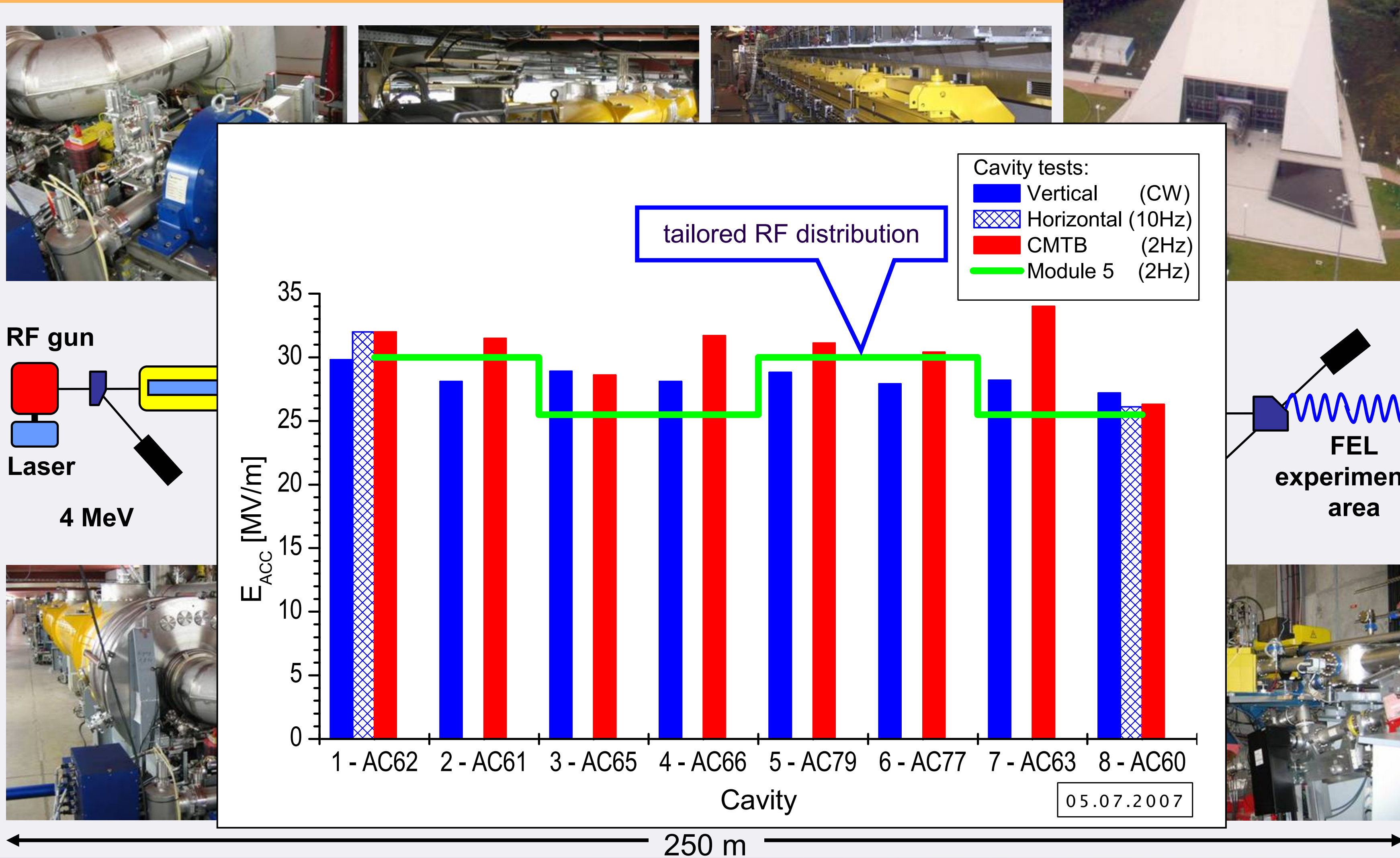
$$\varepsilon_{x,n} = 1.25 \pm 0.19 \text{ mm mrad}$$
$$\varepsilon_{y,n} = 1.27 \pm 0.18 \text{ mm mrad}$$

@1nC

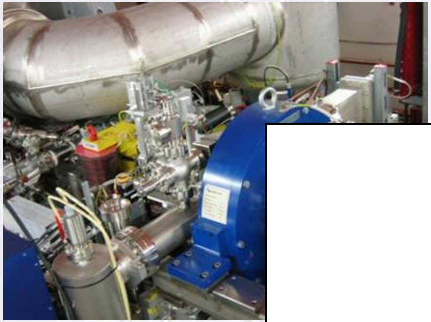
recently reached for 100 % RMS emittance,
i.e. 0.8 mm mrad for 95% RMS w/o tails

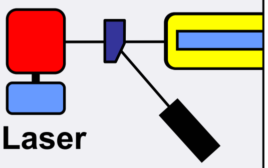
250 m

FLASH Facility



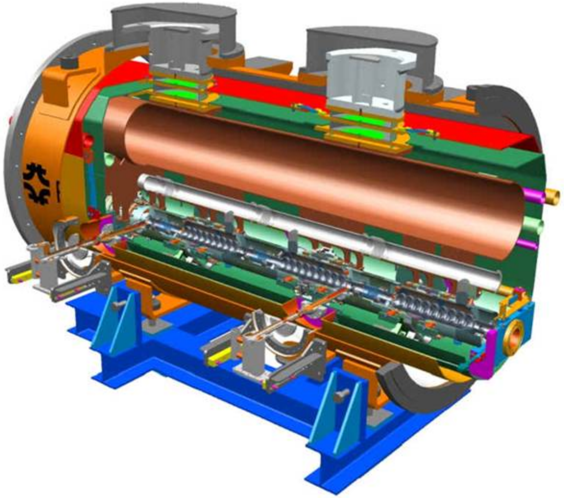
FLASH Facility



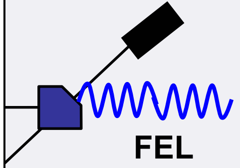


3.9 GHz Module FNAL design

FNAL contribution to FLASH



Needed to linearize longitudinal phase space
to reach shorter wavelength
FNAL assembly kit



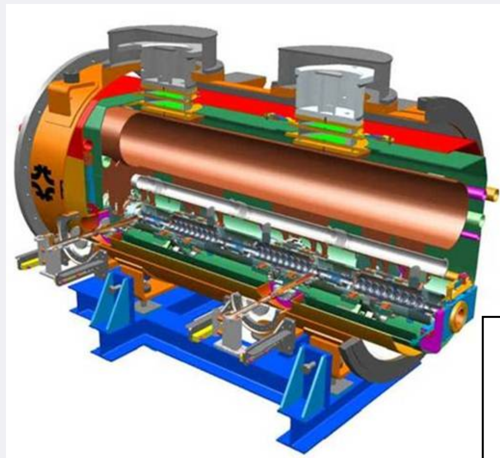
250 m

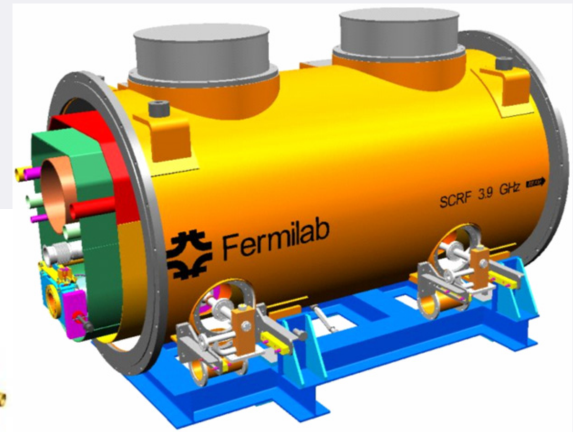
3rd Harmonics RF Cavity

Idea:

Linearization of accelerating voltage in order to linearize phase space distribution → Compress more electrons, Realize >2kA within >200 fs

- TESLA cavity scaled to 3.9 GHz
- all ‚auxiliaries‘ like coupler, HOM coupler, frequency tuner … scaled as well
- most f the work done by H.Edwards et al. / FNAL



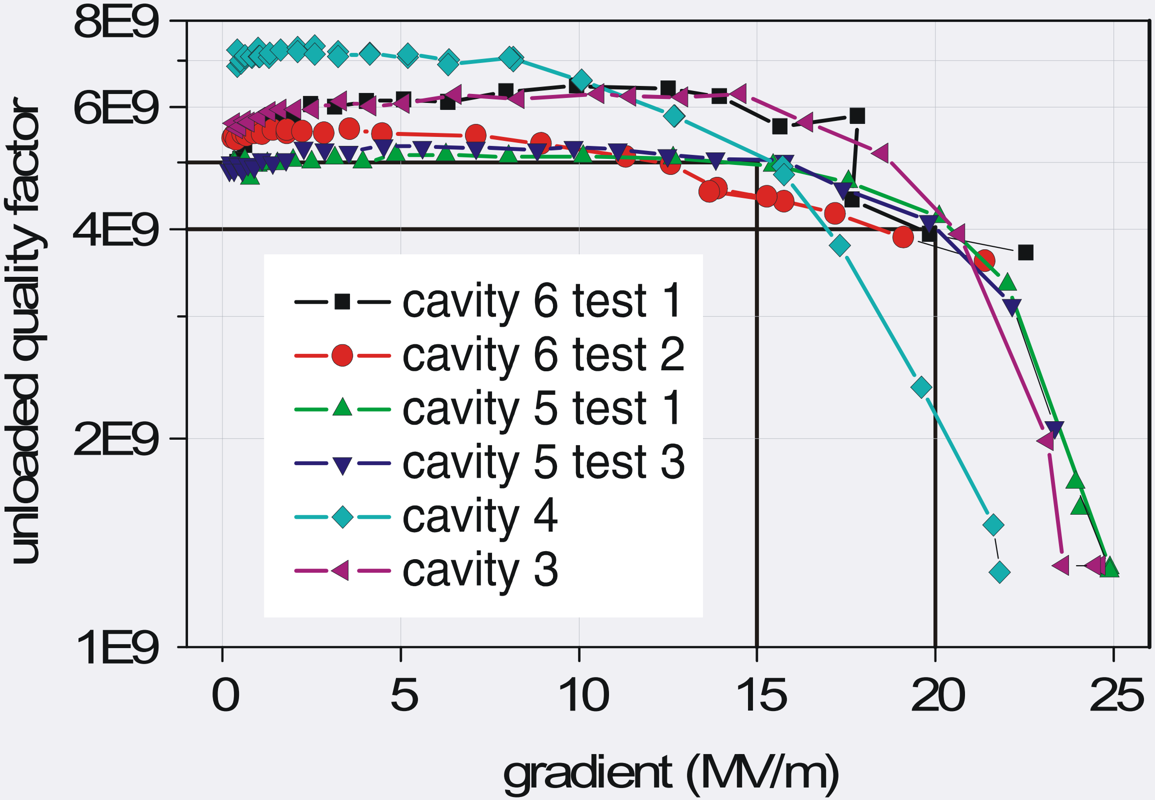


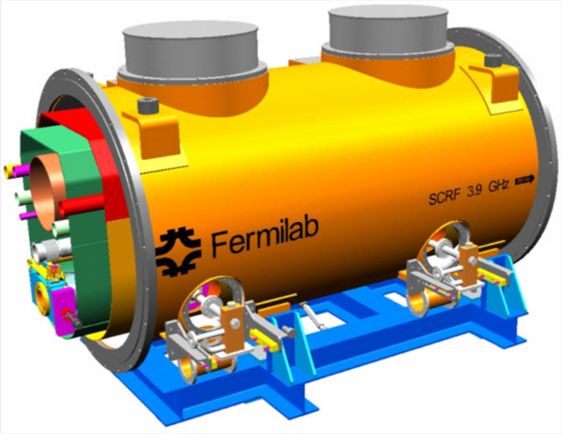
- Produce more photons per pulse, though at longer pulses
- Pre-requiste for all seeding schemes

3rd Harmonics RF Cavity

Cavity performance:

- the design values (15 MV/m) are reached in the vertical test
- the unloaded quality factor matches with BCS



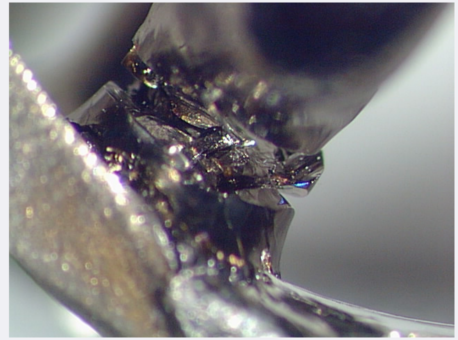


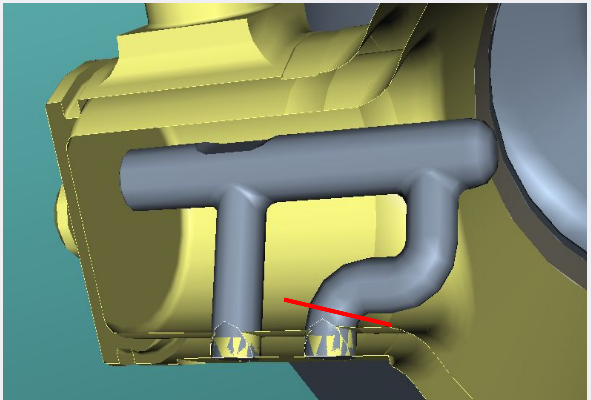
- first helium vessels now at FNAL
- the first horizontal tests are scheduled before the end of 2007

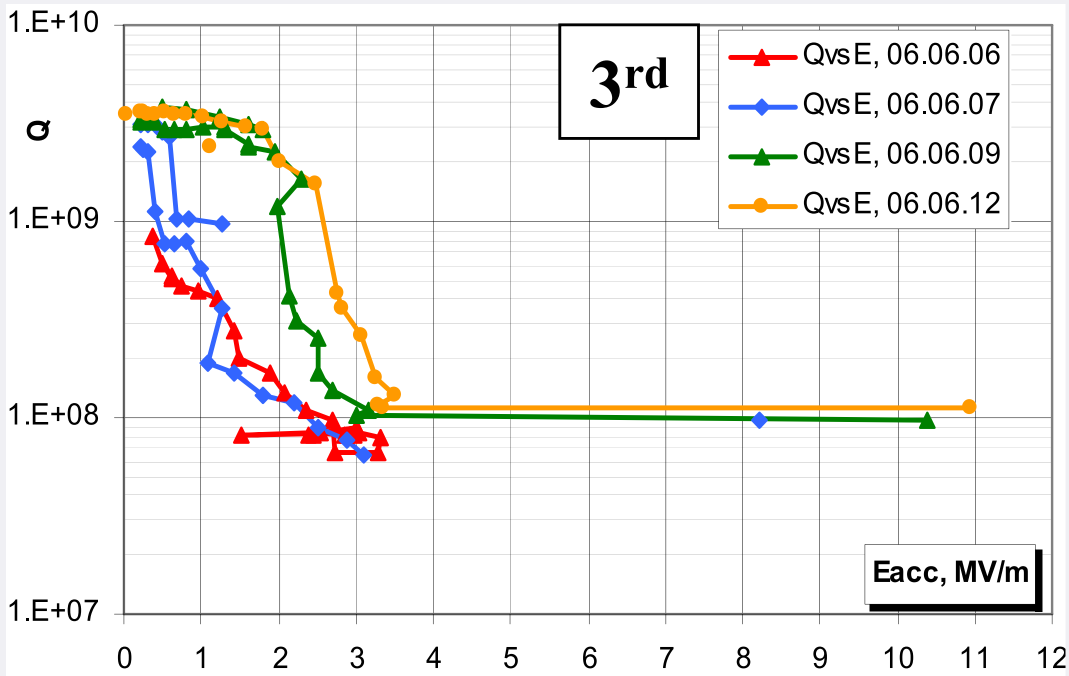
3rd Harmonics RF Cavity

HOM Problem:

- solved by reducing length of double post F-part
- single post F-part should be better concerning multipacting and is attached to latest cavities



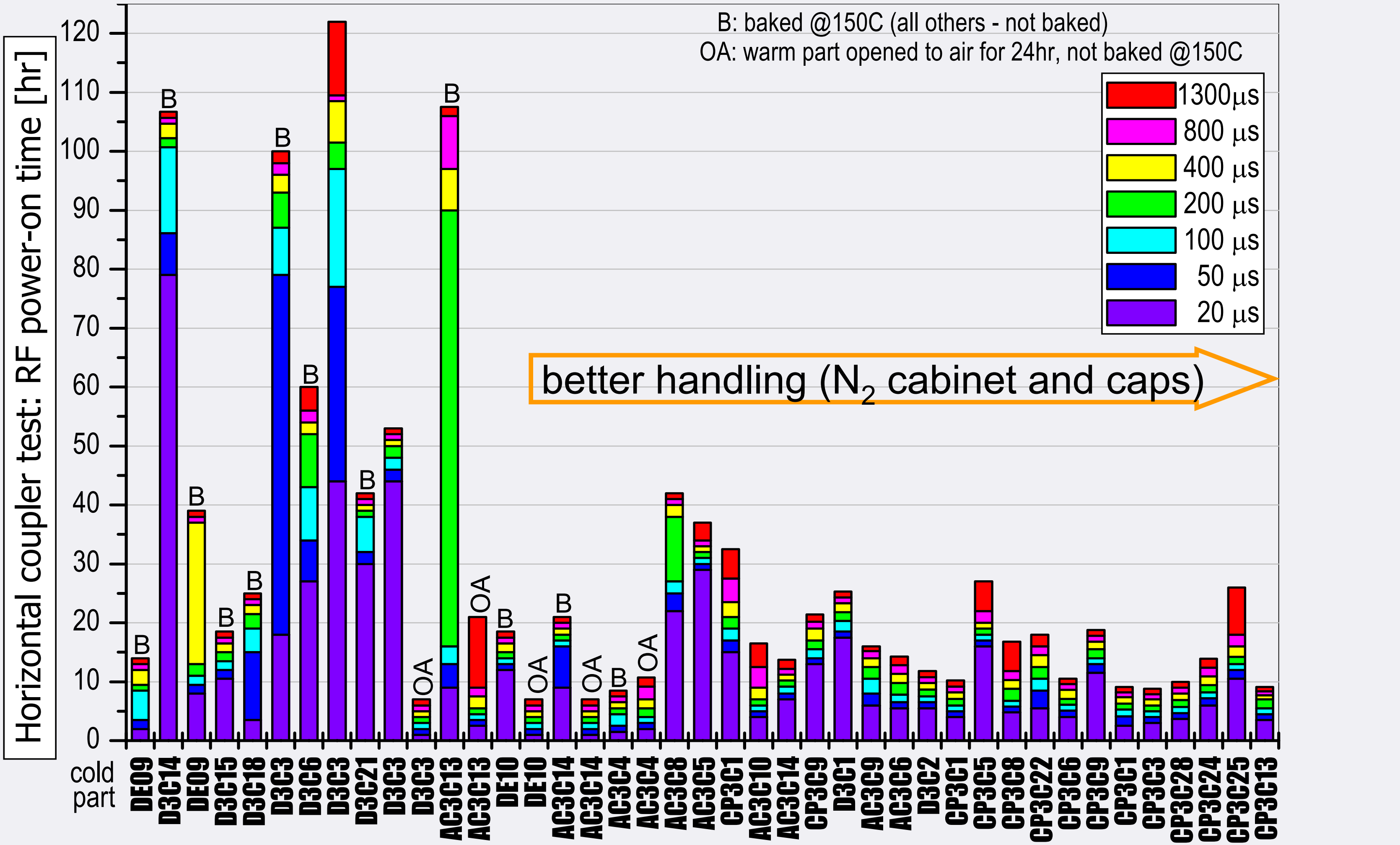




Operation of CMTB *(cryo module test bench)*

- Three modules tested on CMTB → FLASH
- Positive experience for later series tests:
  - Fast conditioning of RF-power coupler
  - Hardly any additional conditioning in FLASH linac necessary
- Good performance of the modules → **design beam energy reached in FLASH**

Fast Coupler Processing Reliably Established



Factory Acceptance Test of the Horizontal Toshiba MBK

Toshiba E3736H at test stand in August 2007 at Toshiba in Nasu, Japan

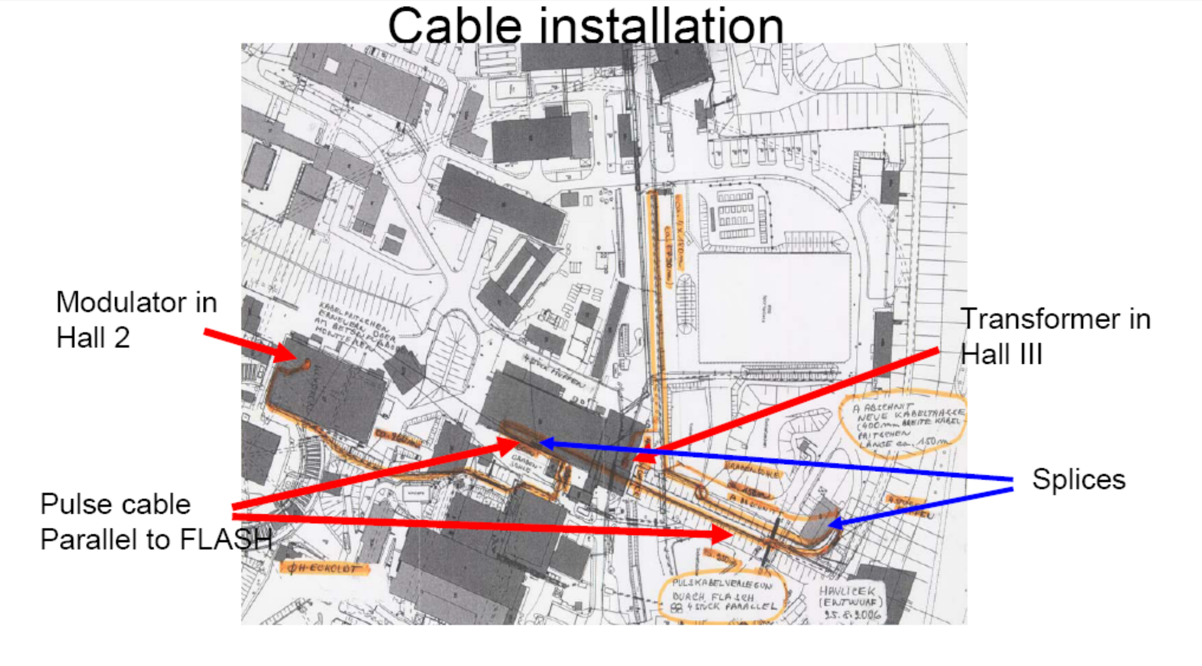
Test Results (Toshiba)		*(design)*
Peak Output Power at 117kV (MW)	10.3	(10)
Efficiency (%)	~67	(65)
Beam Pulse Length (ms)	1.7	
RF Pulse length (ms)	1.5	(1.5)
Repetition Rate (pps)	10	(10)
Saturation Gain (dB)	50	

- Factory Acceptance Test (FAT) in Nasu successfull on August 22/23, 2007
- Klystron arrived at DESY on 18th Sept.
- Site Acceptance Test (SAT) at DESY planned for end of this year

RF System – Modulators, Pulse Cables / EMI

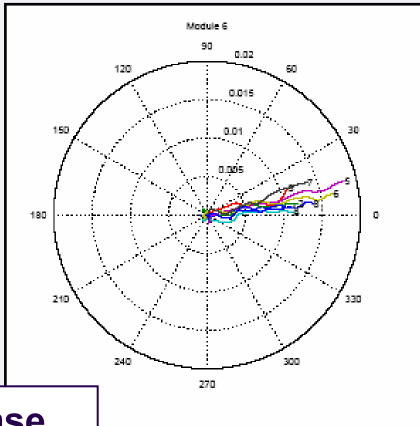
- Modulator prototypes from two manufacturers (CH, NL) under construction → 2008 at DESY, Zeuthen

  3rd company (DE) also qualified with FLASH modulators
- FLASH operates routinely with pulse cables in the tunnel – apparently without EMI problems…



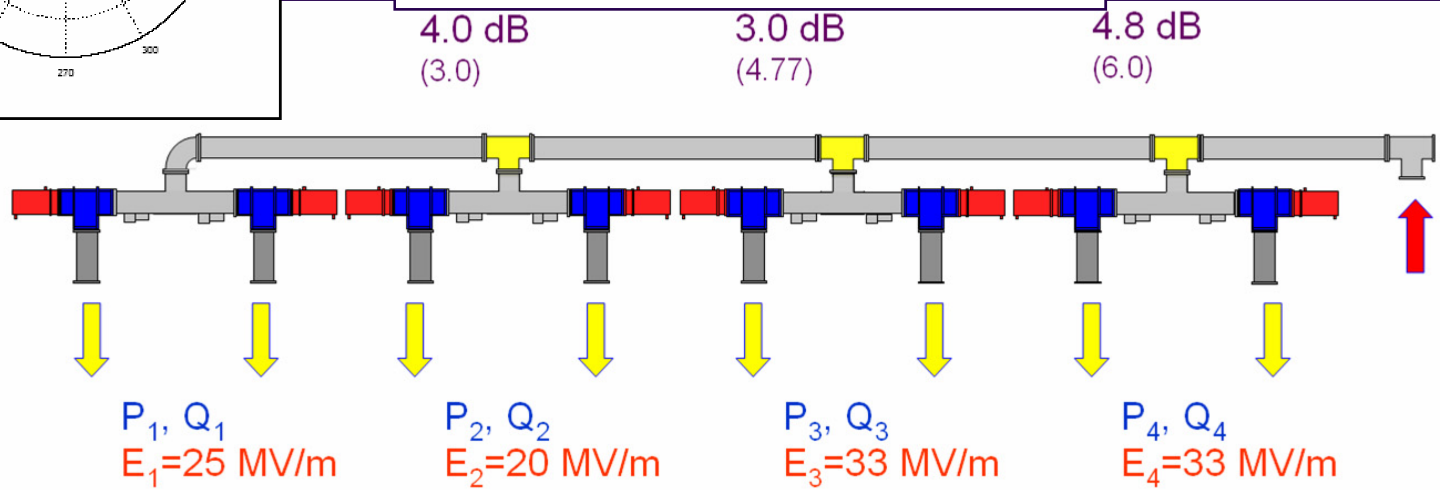
New pre-adjusted waveguide distribution system for ACC6

Power distribution and phase distribution for the individual cavities almost perfect



Initial phase distribution

Waveguide distribution ACC6



Tunnel Mock-Up Completed and Installations Ongoing

The XFEL is based on the feasibility of a single tunnel design including the support of the cryomodules from the ceiling. Installation procedures to be trained at the mock-up.

XFEL

The XFEL Technical Design Report (DESY 2006-097)

M. Tigner, A Possible Apparatus for
Electron Clashing-Beam Experiments
Il Nuovo Cimento Vol. XXXVII, No.3 (1965)

03/2001 XFEL as part of the TESLA LC

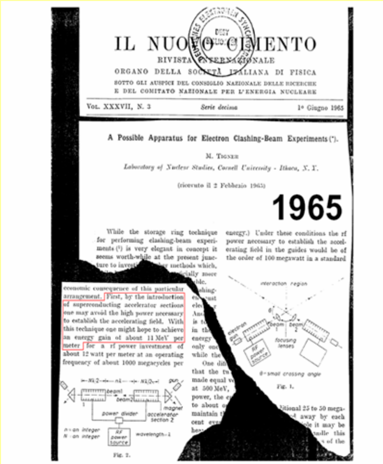
10/2002 Separation of the XFEL

2005 Detailed XFEL accelerator layout

2006 Final TDR incl. detailed technical layout and experiments

2007 project start on June 5th, 2007

The XFEL Technical Design Report (DESY 2006-097)



M. Tigner, A Possible Apparatus for Electron Clashing-Beam Experiments Il Nuovo Cimento Vol. XXXVII, No.3 (1965)

03/2001	**XFEL as part of the TESLA LC**
10/2002	**Separation of the XFEL**
2005	**Detailed XFEL accelerator layout**
2006	**Final TDR incl. detailed technical layout and experiments**
2007	**project start on June 5th, 2007**

International Project Organization

XFEL Steering Committee ISC (Chair: H. Schunck, Germany)

- Representatives of all countries intending to contribute to the XFEL facility
- ***13 countries have signed MoU (project preparation phase)***

CH	CN	DE	DK	ES	FR	GB	GR	HU	IT	PL	RU	SE

- ***European Project Team (Leader: Massimo Altarelli)***

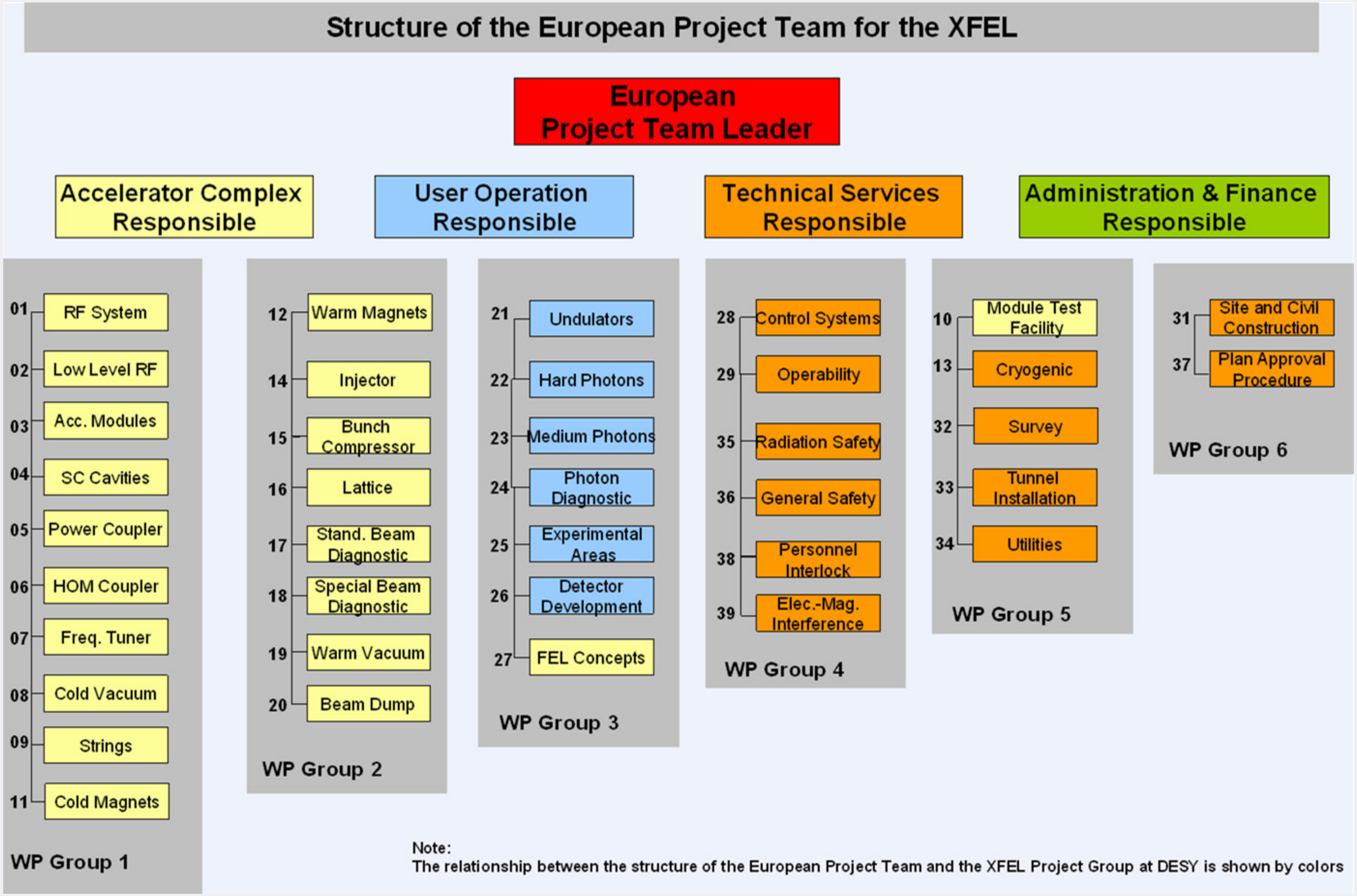
WG on Scientific and Technical issues

WG on Administrative and Funding issues

Bi-lateral negotiations between Germany and signature countries on funding contributions are ongoing.

The MoU for the project phase is still to be signed.

XFEL Project Organization



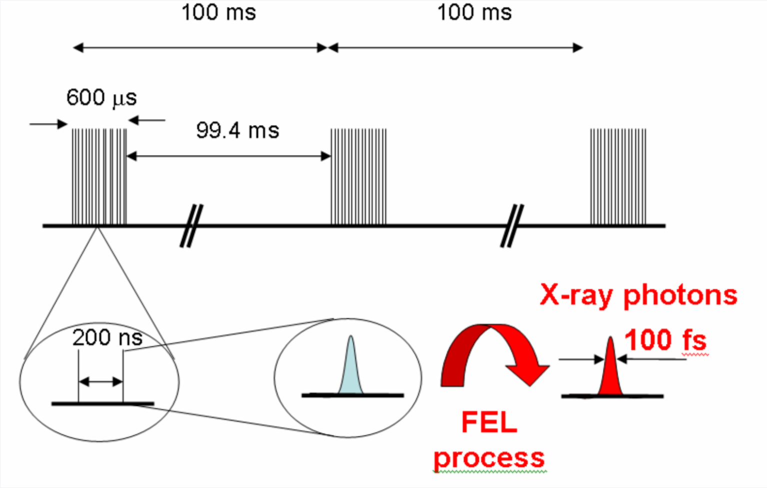
Properties of XFEL radiation

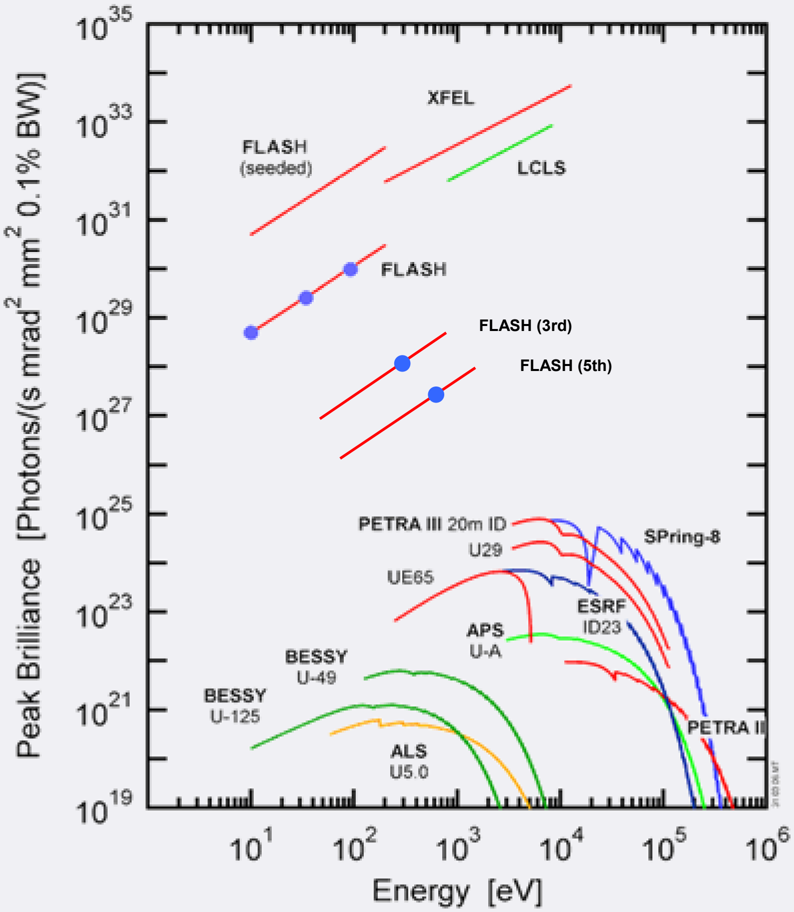
X-ray FEL radiation (0.2 - 14.4 keV)

- ultrashort pulse duration <100 fs (rms)
- extreme pulse intensities 10^{12}-10^{14} ph
- coherent radiation x10^9
- average brilliance x10^4

Spontaneous radiation (20-100 keV)

- ultrashort pulse duration <100 fs (rms)
- high brilliance





~ 260 scientists at 1st XFEL users meeting

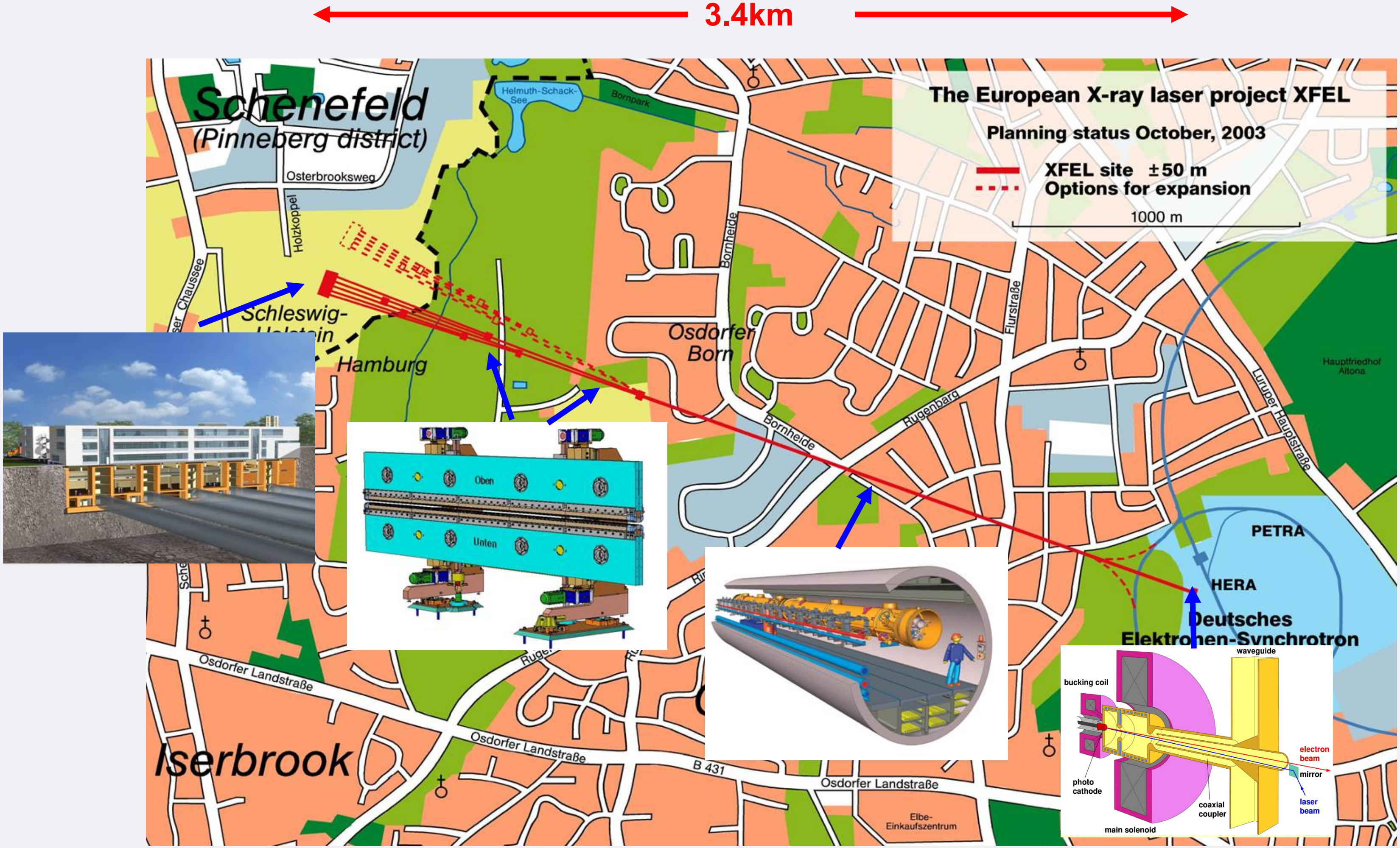
First European XFEL Users' Meeting

January 24/25, 2007, Main Auditorium (Bldg 5), DESY, Hamburg

Final Program

	Wednesday, January 24, 2007		
08:15-09:00	**Registration**		
09:00-10:30	**Welcome session**	**Speakers**	
	Welcome remarks	A. Wagner (DESY) R. Koepke (BMBF) J. Wood (CCLRC)	
	Reports from the International Steering Committee (ISC) for the European XFEL and its advisory groups	H. Schunck (ISC) R. Feidenhans'l (Scientific and Techn. Issues) H.-F. Wagner (Admin. and Funding Issues)	
	Coffee break		
10:45-12:45	**Project Status Reports**	**Chair: J. Schneider**	DESY Hamburg
10:45	Overview	M. Altarelli	Europ. XFEL Proj. Team
11:15	The superconducting accelerator	R. Brinkmann	Europ. XFEL Proj. Team
11:45	Photon beam systems	Th. Tschentscher	Europ. XFEL Proj. Team
12:15	Detector development for the XFEL	H. Graafsma	DESY Hamburg
	Lunch break		
14:00-16:20	**Scientific Perspectives (I)**	**Chair: I. Lindau**	SLAC Stanford
14:00	Ultrafast processes and extreme conditions	J. Wark	Oxford University
14:35	Ultrafast structural changes	R. Feidenhans'l	Copenhagen University
15:10	Time-resolved molecular reactions	M. Chergui	EPFL Lausanne
15:45	Investigation of small quantum systems	J. Ullrich	MPI Heidelberg
	Coffee break		
16:40-18:25	**Scientific Perspectives (II)**	**Chair: I. Robinson**	UC London
16:40	Dynamics of nanoscale systems	G. Grübel	DESY Hamburg
17:15	Imaging of single particles	H. Chapman	LLNL Livermore
17:50	Matter in intense x-ray fields	P. Zeitoun	LOA Palaiseau
18:25	End of session		
19:00	**Dinner for participants (DESY Canteen, Bldg 9)**		

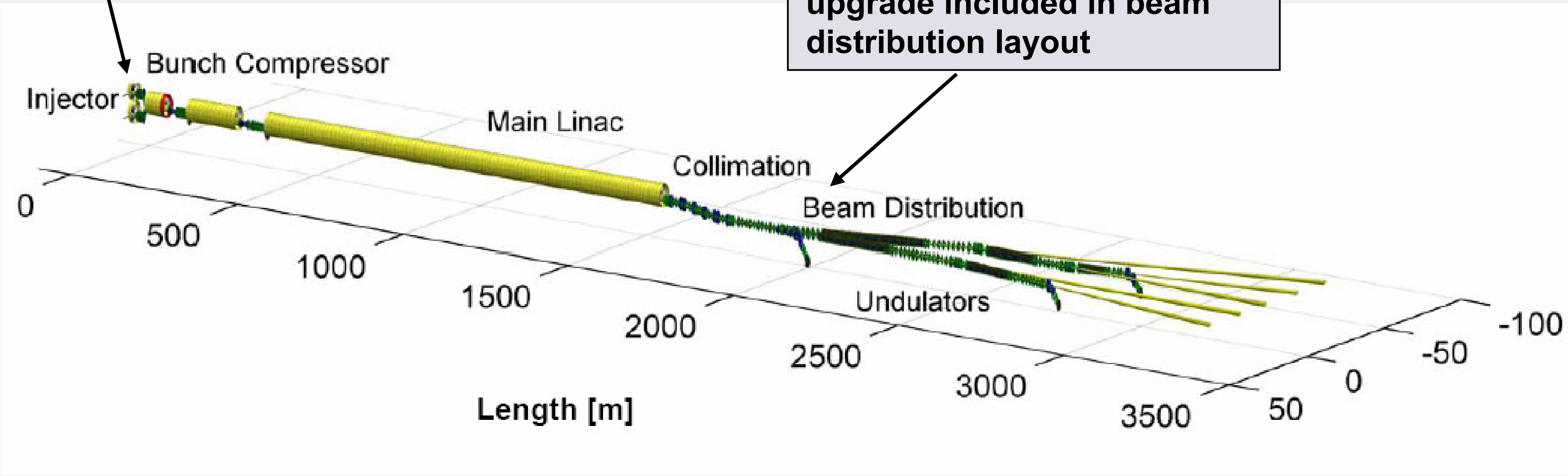
Overall layout of the European XFEL



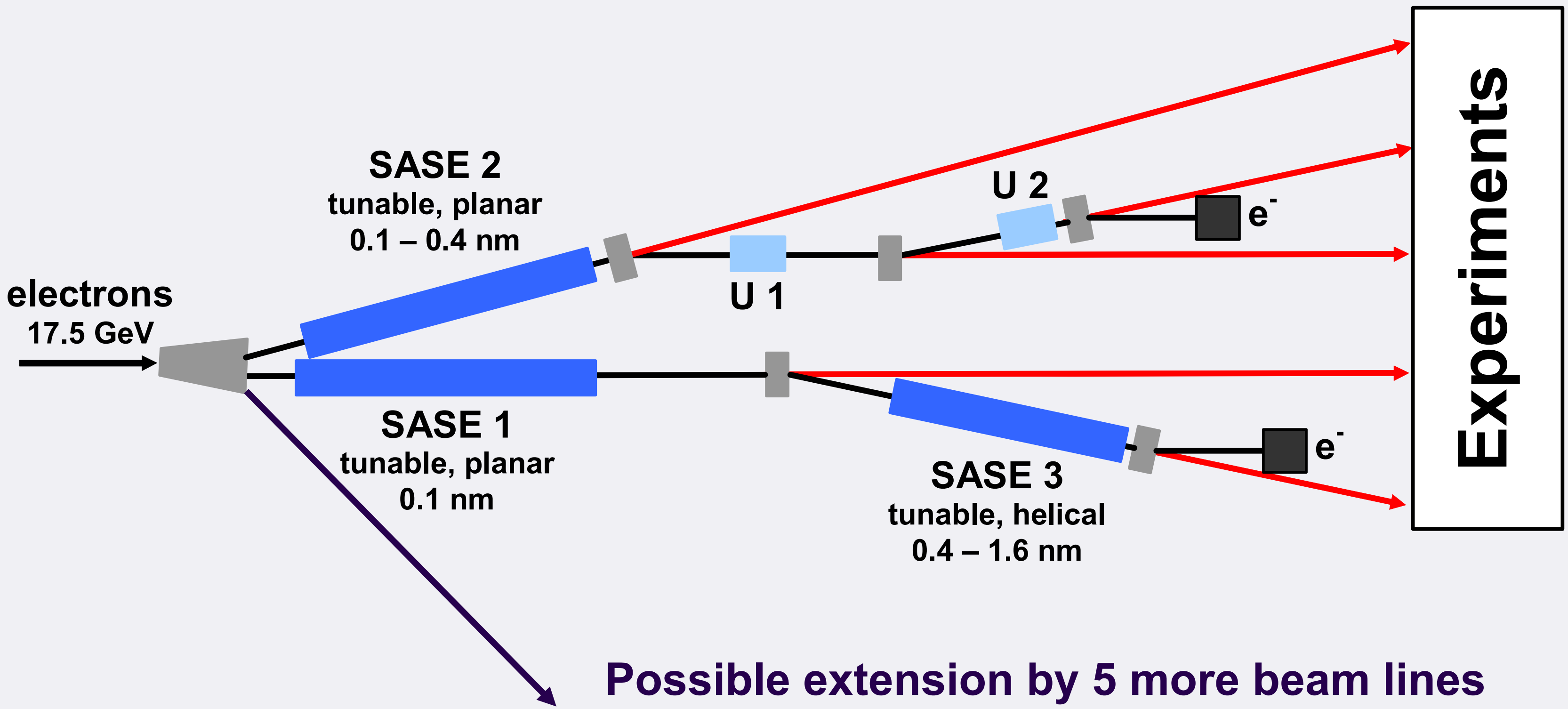
Accelerator layout

One injector initially installed

Connection to 2nd stage upgrade included in beam distribution layout



Photon Beam Lines (TDR Layout)

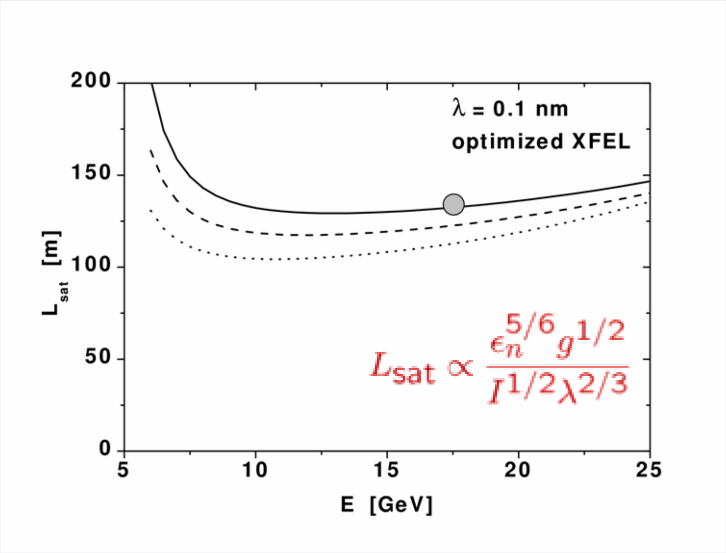


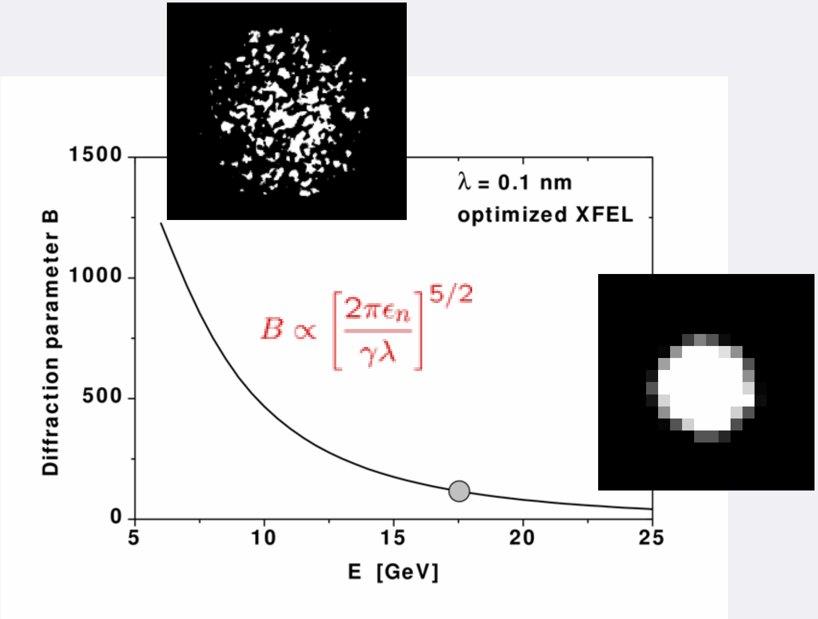
Possible extension by 5 more beam lines and 10 experimental stations

Start-up scenario has only 3 undulator beam lines.

Choice of Beam Energy: 17.5 GeV for 0.1nm Wavelength

gap = 6 mm, 8mm, and 10 mm





→ Good photon beam coherence

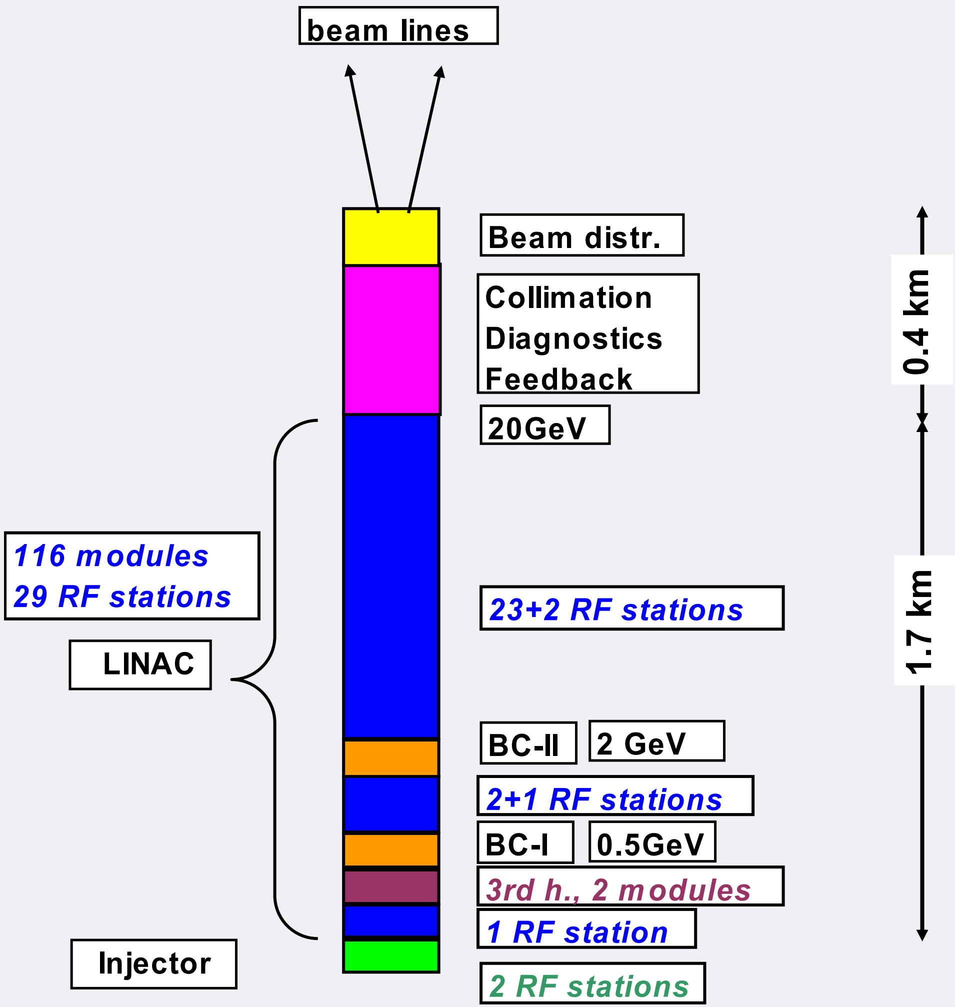
(65 – 85% at 0.1 – 0.15nm, ε_n = 1.4mm*mrad)

XFEL Accelerator Layout

XFEL TDR included reserve units to provide high operational availability.

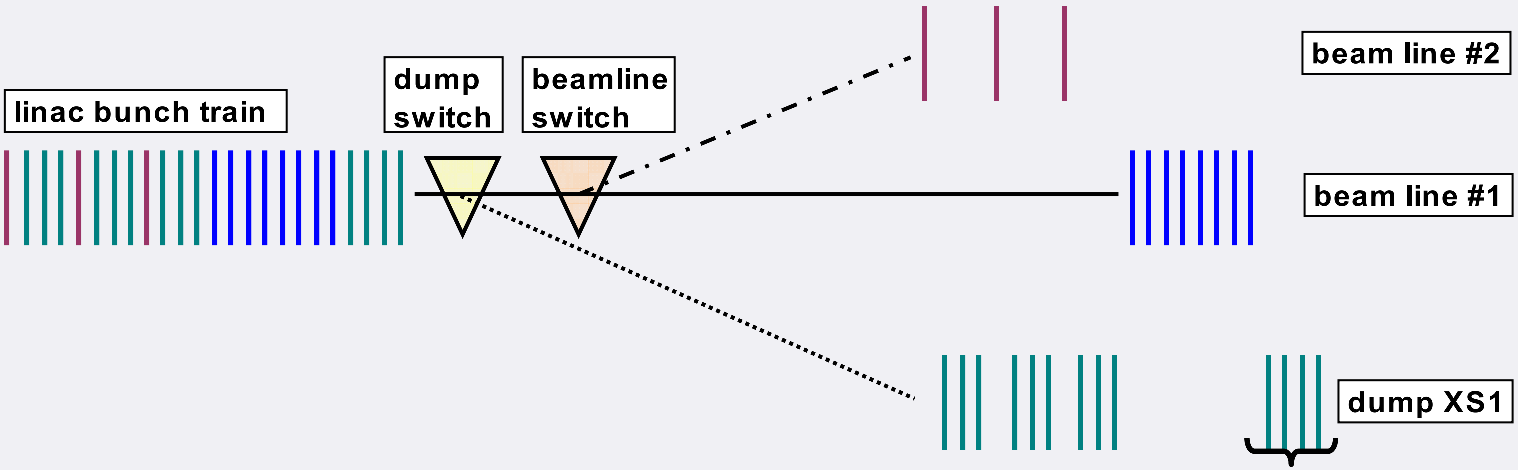
The design accelerating gradient of 23.6 MV/m aimed for 20 GeV – potential for energy upgrade.

The actual funding scenario leads to a reduction in the number of accelerator modules (101 in total). But a safe operation at 17.5 GeV can be assumed.



Operational Flexibility

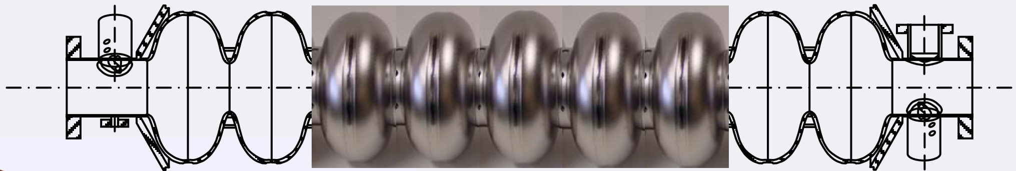
Different beam time structure to different experiments – concept using kicker devices permits large flexibility without having to change the (preferably homogenous) bunch train structure in the linac



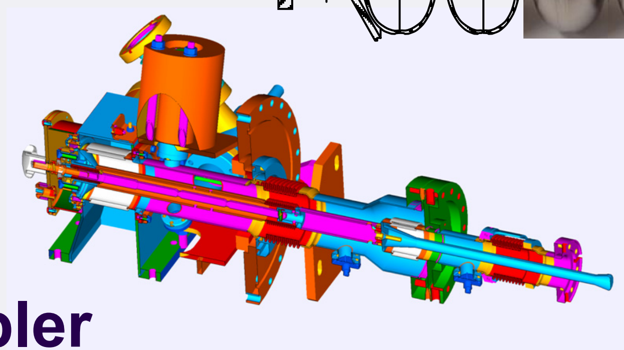
Fast intra-bunch train feedback system → **"Steering bunches"**

XFEL Accelerator Components

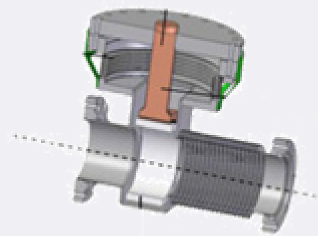
cavities



TESLA Technology

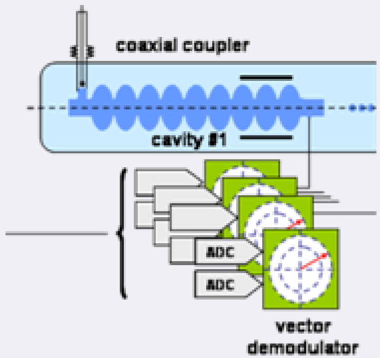


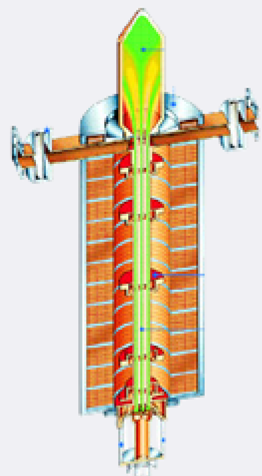
coupler



HOMs

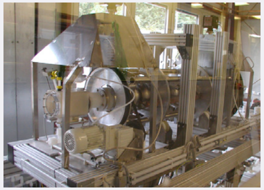
LLRF





RF

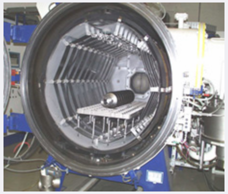
Cavity Prep. (XFEL Industrial Production)



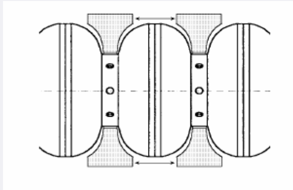
EP 150 µm (inside)

4 bar rinse

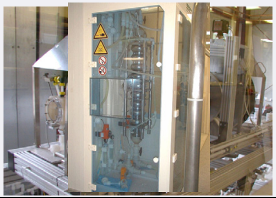
BCP 20 µm (outside)



UHV 800°C annealing

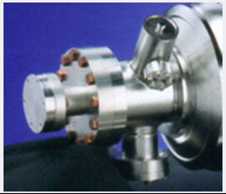


freq./ field flatness tuning

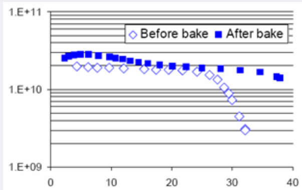


FLASH BCP < 10 µm

100 bar HPR



inst. pick-up / HOM



UHV 120°C baking

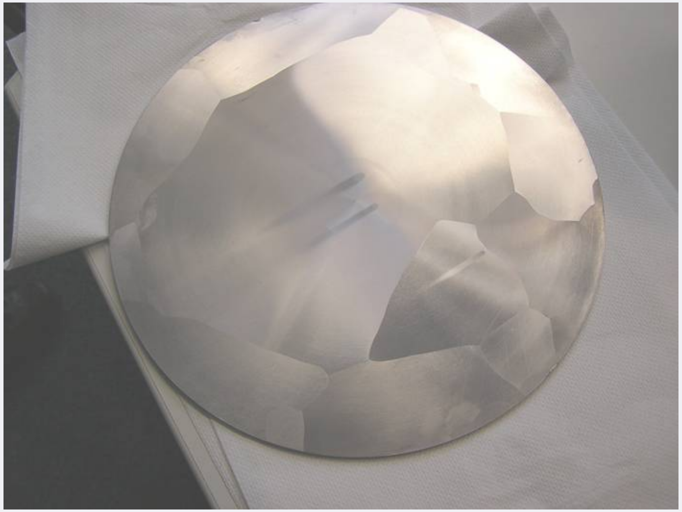
100 bar HPR (6 ×)

1. electro-chemical removal of a thick niobium layer (so-called damage layer) of about 150 µm from the inner surface
2. a rinse with particle free / ultra-pure water to remove residues form the electro-chemical treatment
3. outside etching of the cavities of about 20 µm
4. ultrahigh vacuum annealing at 800°C
5. tuning of the cavity frequency and field profile
6. removal of a thin and final layer of about 30 µm
7. rinsing with particle free / ultra pure water at high pressure (100 bar) to remove surface contaminants
8. assembly of auxiliaries (pick-up probe and HOM pick-up)
9. baking at 120°C in ultra high vacuum
10. additional six times rinse with high pressure ultra-pure water (100 bar)

Alternative Fabrication – Large Grain Nb

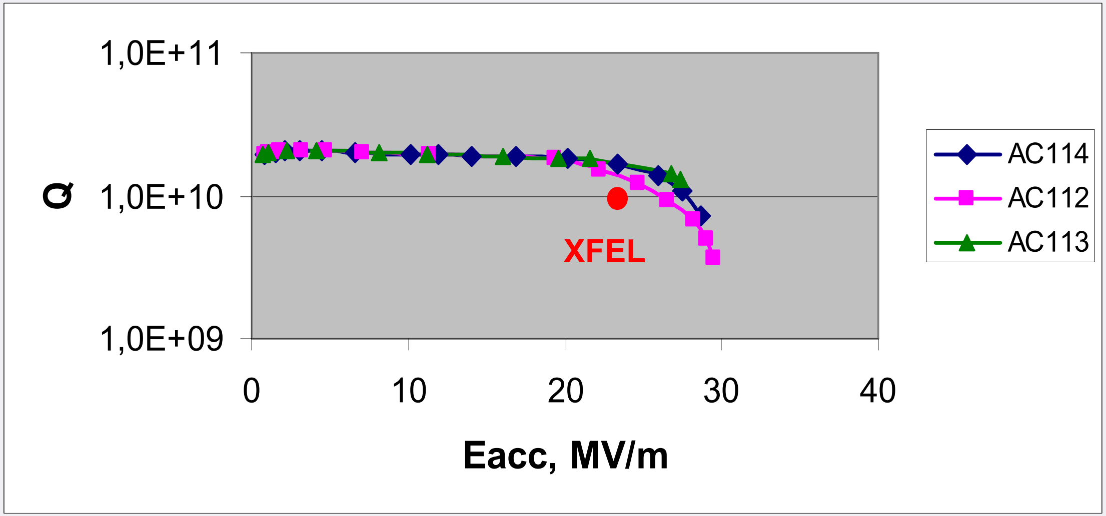
Fabrication from large-grain Niobium – cut sheets directly from ingot (method pioneered by JLAB)

After initial good results with single cells, fabricated and tested three 9-cell cavities – only BCP-treated, no EP!

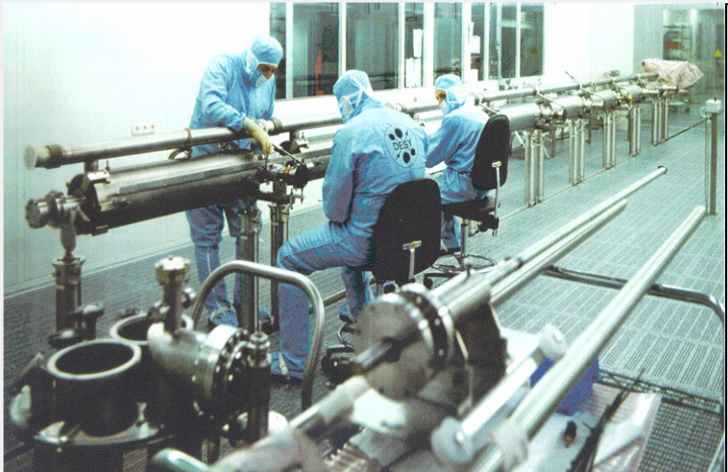


→Will build 6 more cavities, possibly alternative fabrication/treatment procedure

→Could later choose the more economic method for industrial production



Cavity String Assembly



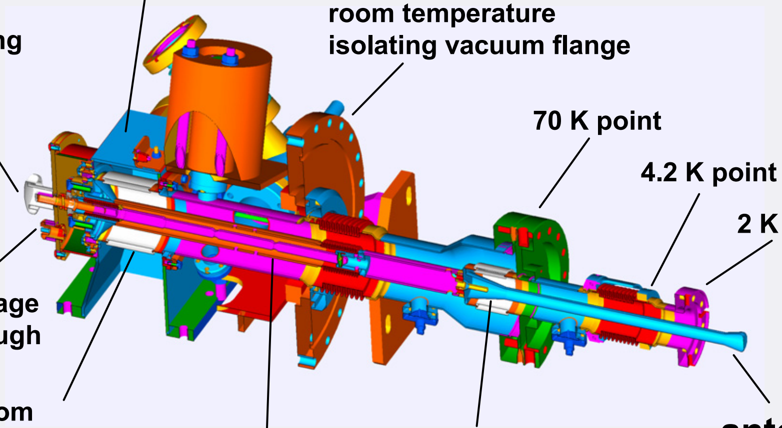
The assembly of an 8 cavity string

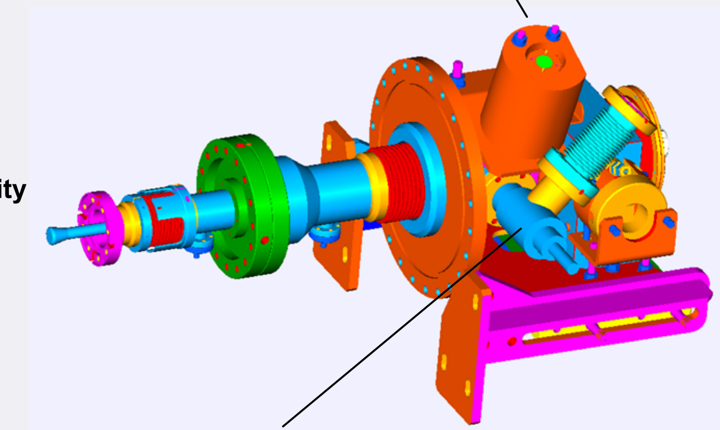
- is a standard procedure at DESY and was also recently done at FNAL.
- was done by technicians from the TESLA Technology Collaboration
- was the basis for two industrial studies.

The transfer of this well known and complete procedure to industry is ongoing.

DESY has provided sub-components for the first string / module built by industry; this allows for an early training.

Auxiliaries – Main RF Power Coupler





At 20 GeV design energy 120 kW are required for the 650 μs long beam pulse; with 10 Hz rep rate and 720 μs filling time the average power amounts to 1.6 kW.

Q_{ext} can be varied in the range of $10^6 – 10^7$. At 23.6 MV/m the optimum Q_{ext} is 4.6×10^6.

Couplers were tested to transmit 1.5 MW of peak RF power in traveling wave mode and 600 kW / 5 Hz in standing wave mode. In a 35 MV/m cavity test, one coupler was operated 2,400 hours at 2.5 kW average RF power.

The two window solution protects the cavity vacuum. Multipacting is suppressed by the coaxial line's design and additional bias voltage (up to 5 kV)

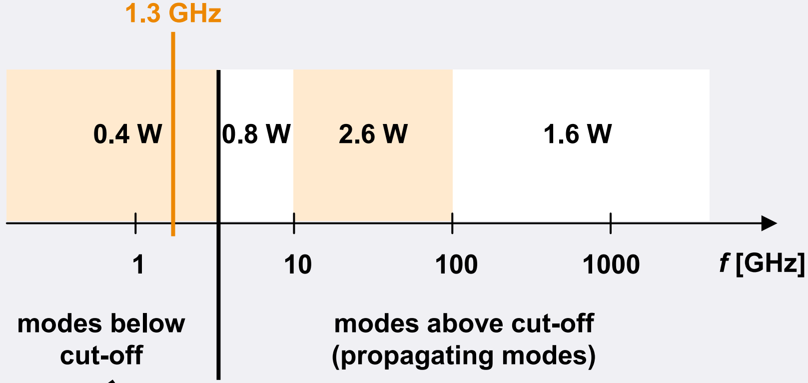
Industrial studies for 1,000 couplers are done at LAL Orsay. The production of 30 couplers was supervised and the conditioning done at Orsay with great success. Another 30 couplers will be produced soon.

Damping of Higher Order Modes (HOMs)

The spectrum of the electron bunch (σ_z = 25 µm) reaches high frequencies up to 5 THz.

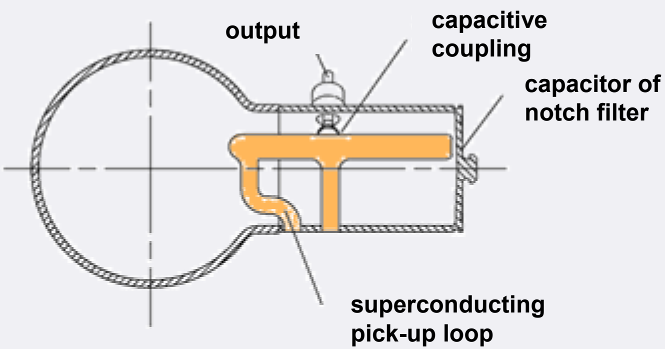
The standard accelerator module has an integrated loss factor of 135 V/pC.

The total power deposited by the nominal beam is 5.4 W per module.

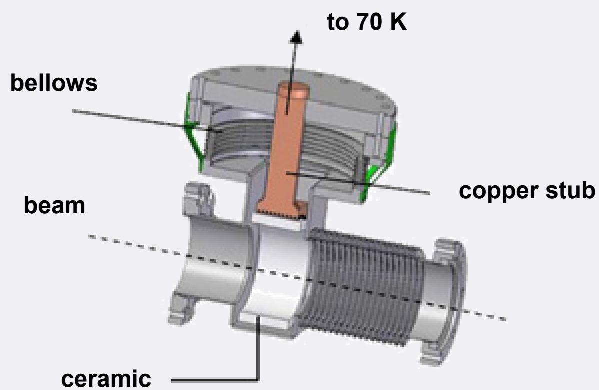


The design of the HOM coupler and the beam pipe absorber take into account a possible XFEL upgrade (more bunches / CW mode).

The HOM coupler was tested in CW mode. The absorber is specified for 100 W.

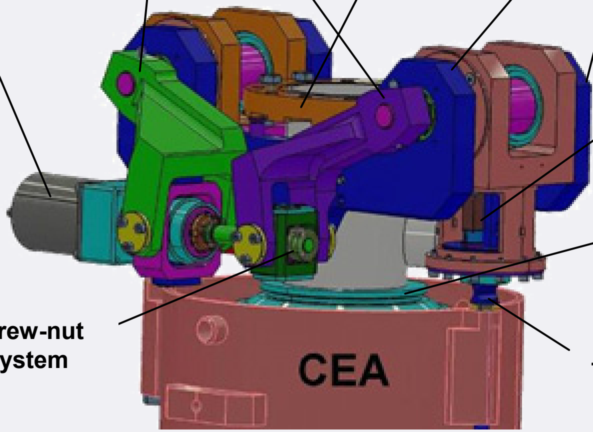


HOM coupler

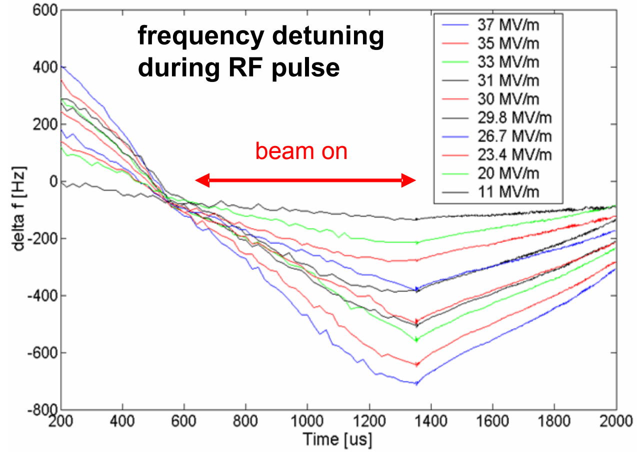


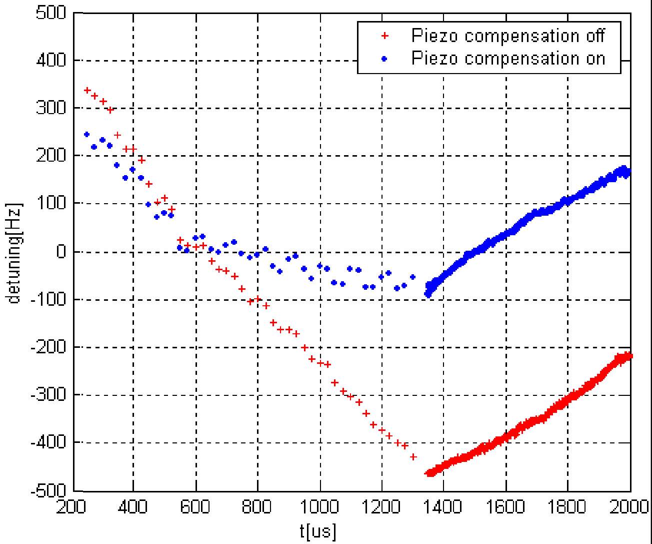
beam pipe absorber

Slow and Fast Frequency Tuner



The helium vessel acts as the mechanical reference (the titanium bellows is not shown)



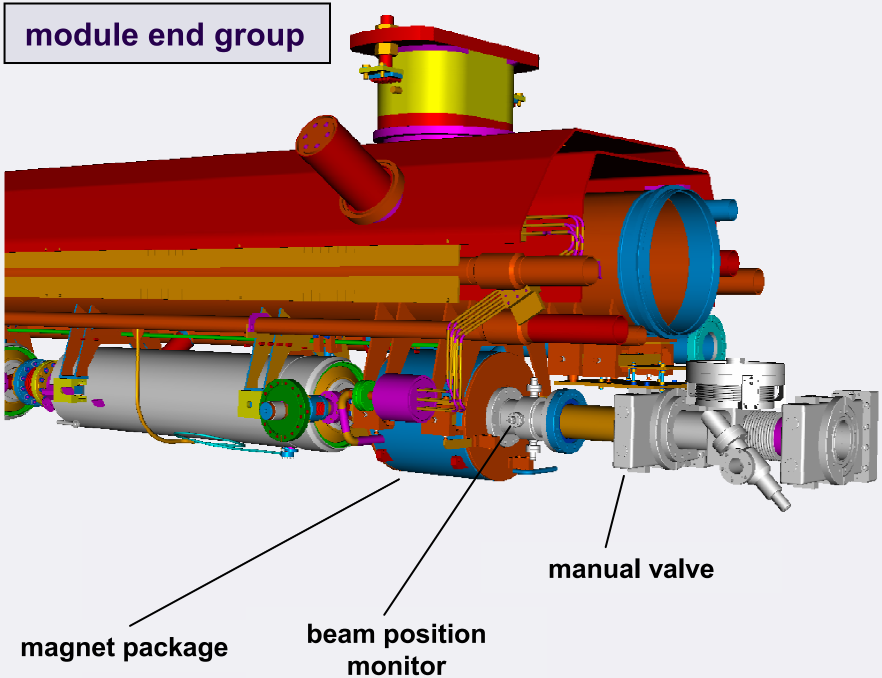


The slow tuner compensates for drifts; 400 kHz range , 1 Hz resolution

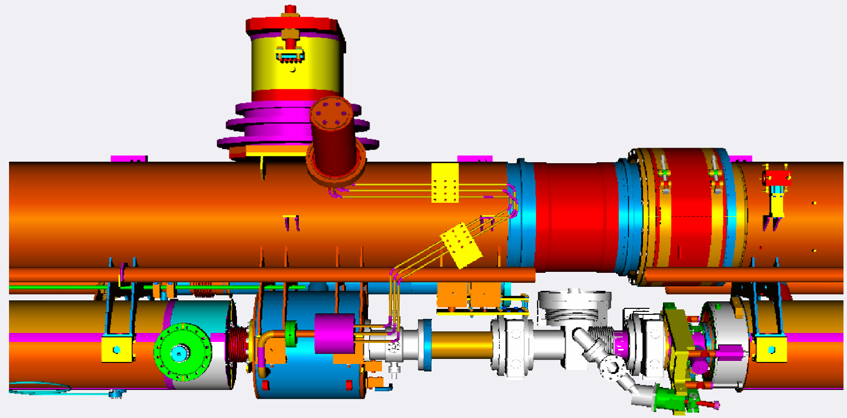
The fast tuner compensates the Lorentz-Force detuning during the RF pulse. It is based and piezo crystals.

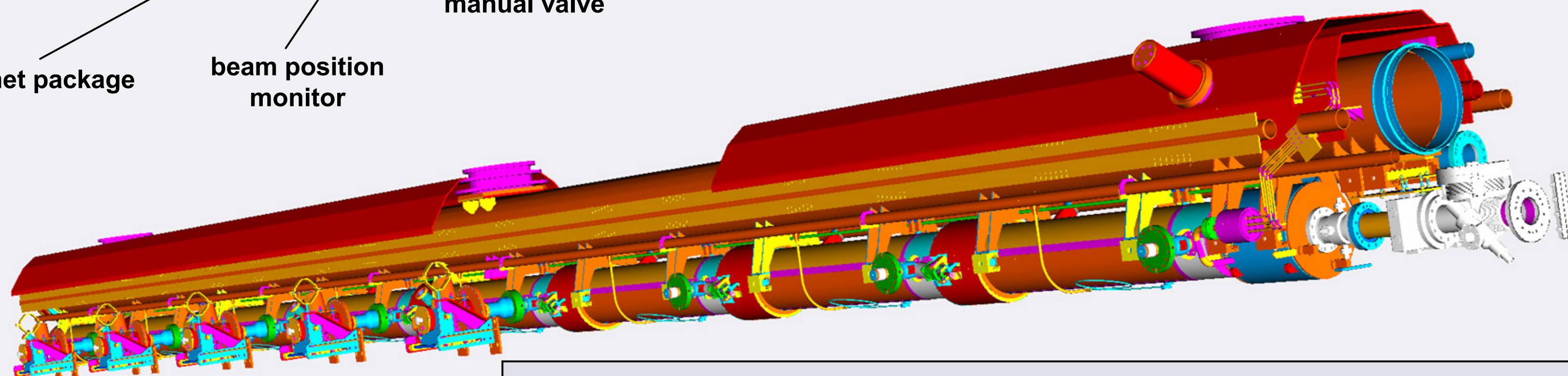
Accelerator Module (Cryomodule)

module end group



module to module connection





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

Accelerator Module (Cryomodule)

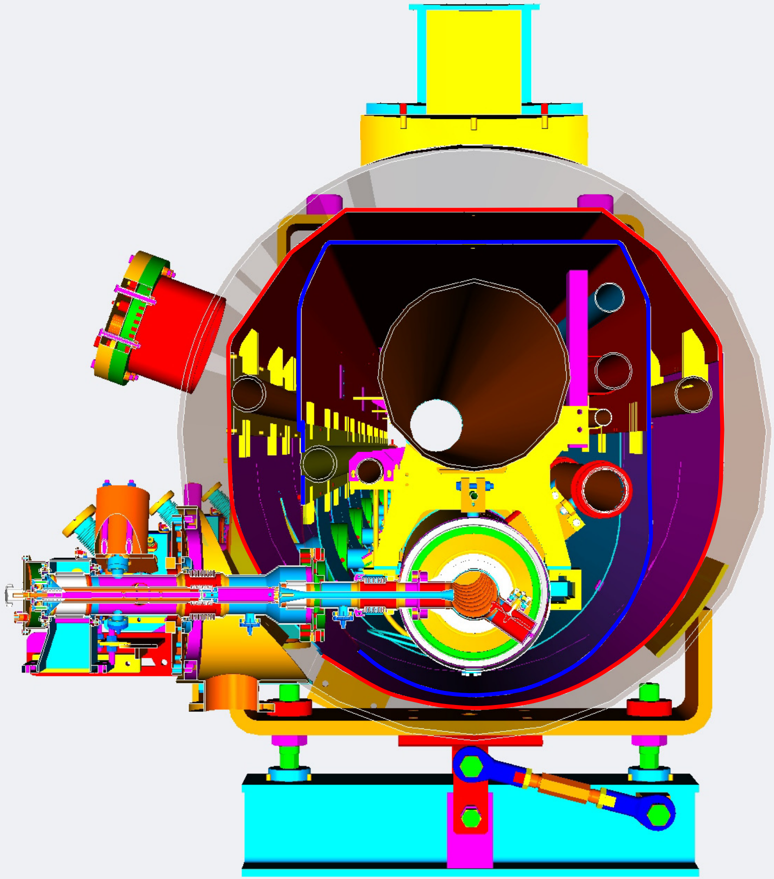
The XFEL accelerator module is based on the 3rd cryomodule generation tested at the TESLA Test Facility and designed by INFN.

Already 10 cryomodules have been built and commissioned for the TTF Linac.

Module 6 and Module 7 (repl. ACC3) were installed last. And allow for the 1 GeV operation.

Up to 4 additional cryostats will be available until end of 2008.

Then series production of 101 modules.



38" carbon steel vessel

300 mm He gas return pipe acting as support structure

8 accelerating cavities

cavity to cavity spacing exactly one RF wavelength

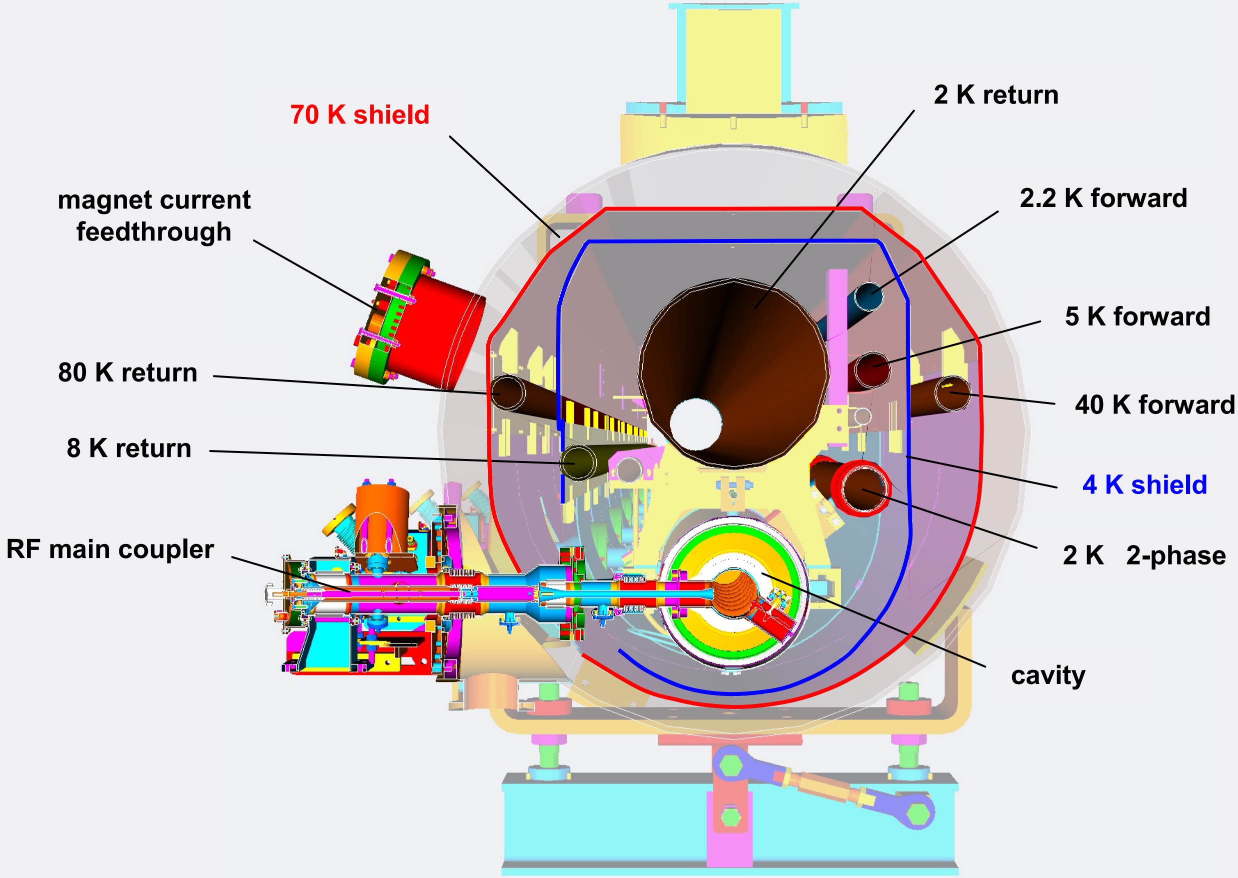
inter-module cavity to cavity spacing a multiple of one RF wavelength

one beam position monitor / magnet unit

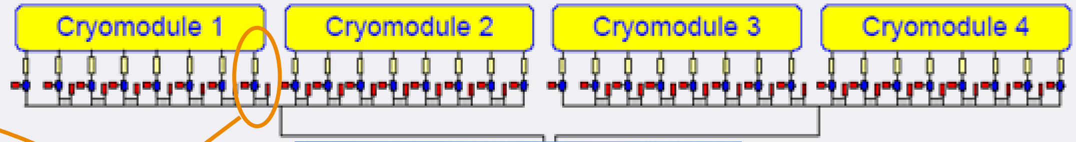
manually operated valves to terminate the beam tube at both ends

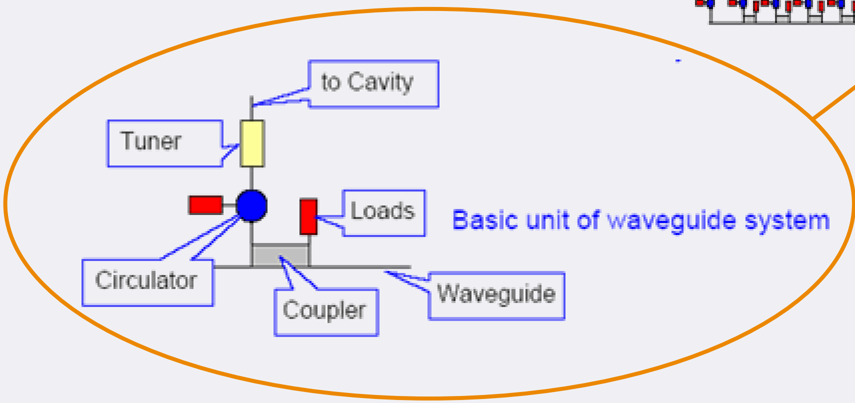
longitudinal cavity position independent from the contraction / elongation of the HeGRP during cool-down / warm-up procedure

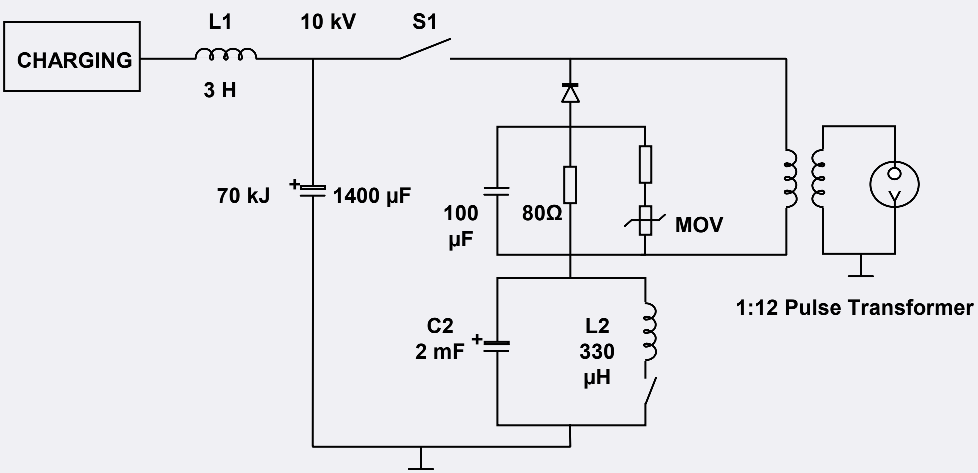
Accelerator Module (Cryomodule)



High Power RF System







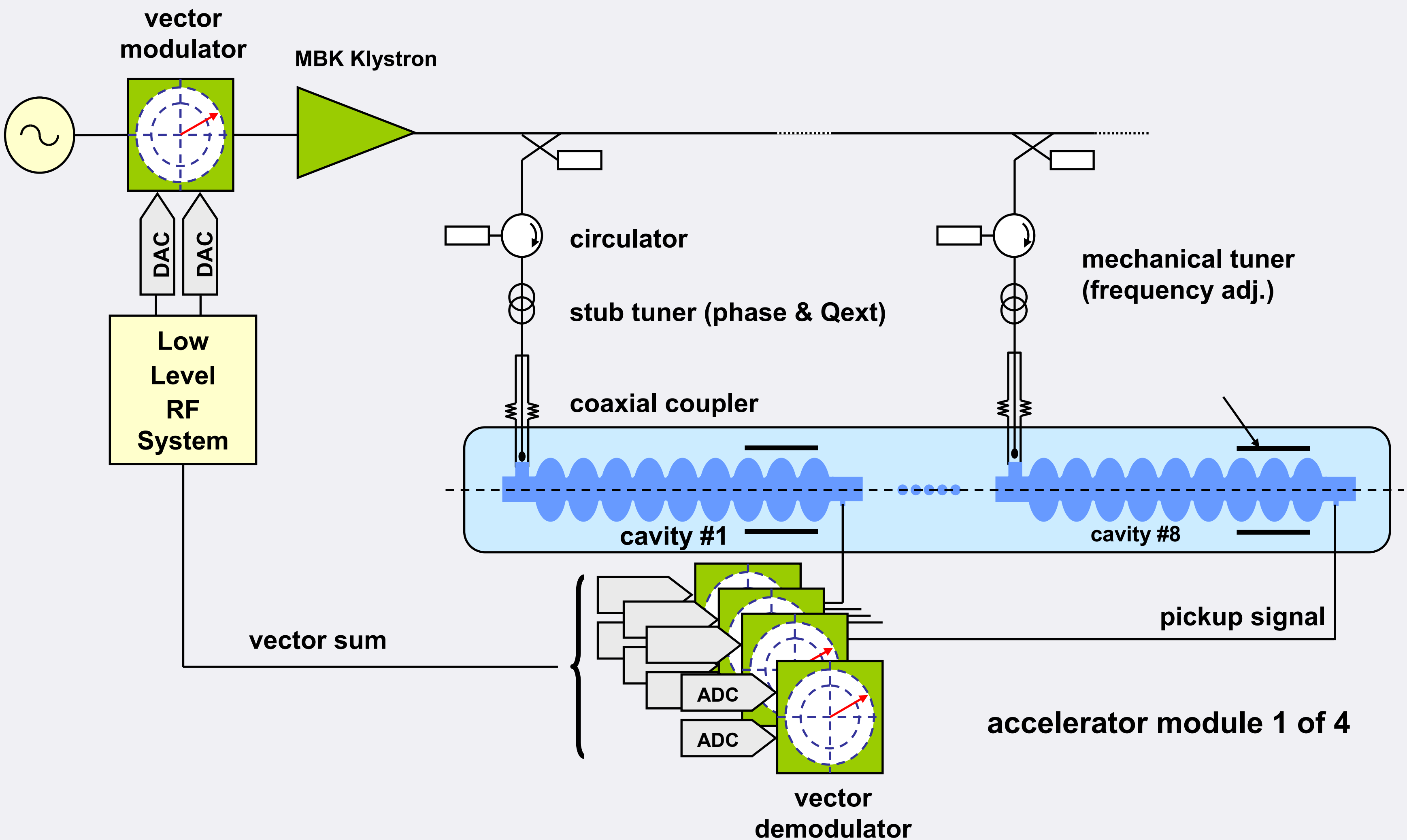

Toshiba E3736

31 RF stations provide 10 MW peak and 150 kW average.

3.9 MW are required at nominal beam parameters and 20 GeV.

Incl. waveguide losses (6%) and regulation reserve (15%) 5.2 MW.

Low Level RF Control



Low Level RF Control

Amplitude and Phase Stability

Design parameter are based on

- **bunch-to-bunch energy spread**
- **pulse-to-pulse energy spread**
- **bunch compression in the injector**
- **arrival time of the beam at the undulator**

The injector RF system needs 0.01% amplitude and 0.01 deg phase stability!!!

(stability of photon intensity)

TEST at FLASH

Operational Requirements

Beside field stabilization, the RF system must provide

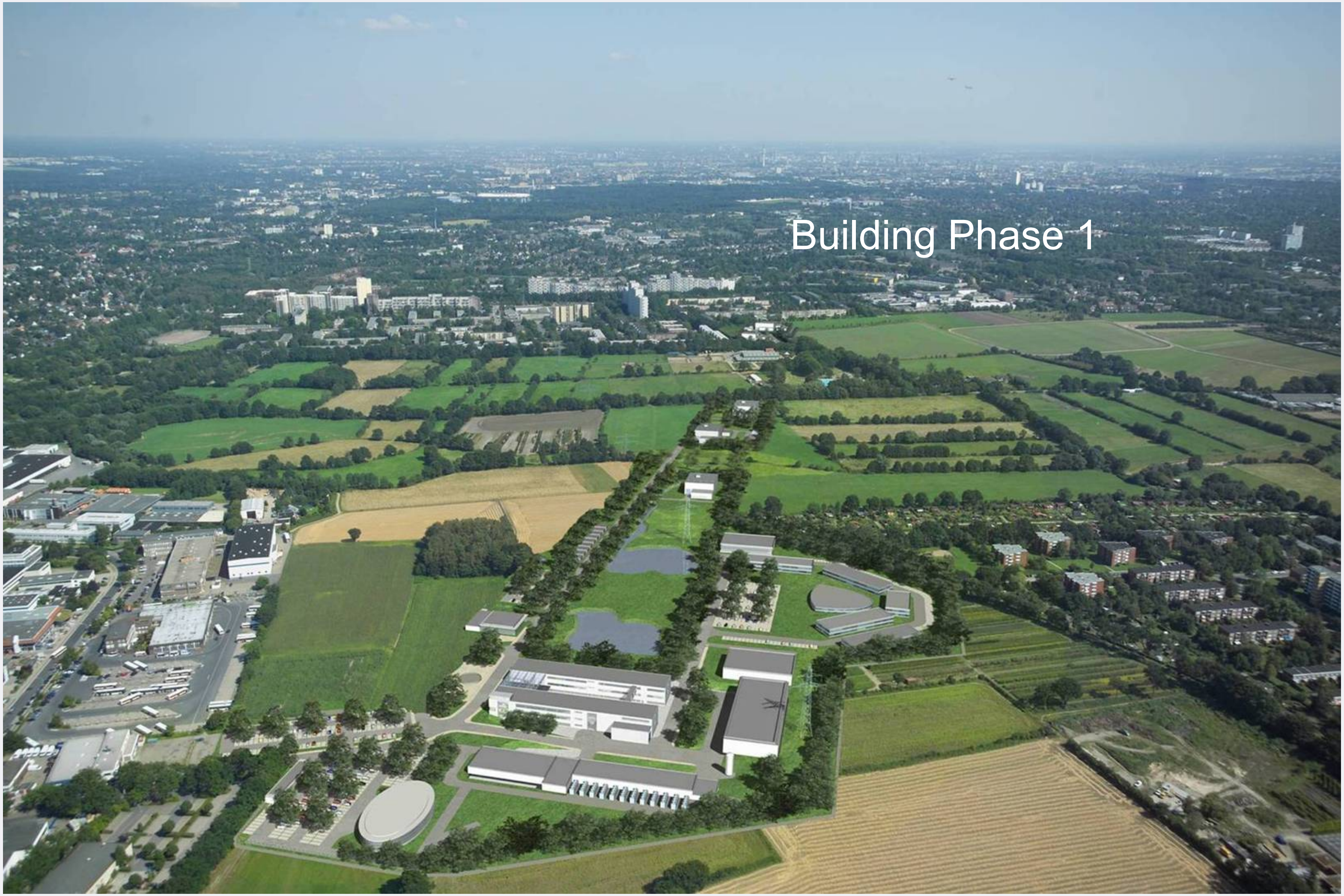
- **diagnostics for the calibration of gradient and beam phase**
- **measurement of the loop phase**
- **measurement of the cavity detuning**
- **control of the cavity frequency tuners (use fast tuner to correct Lorentz Force detuning)**
- **exception handling capability to avoid beam loss and to allow for maximum operable gradient**

  e.g. cavity quench detection

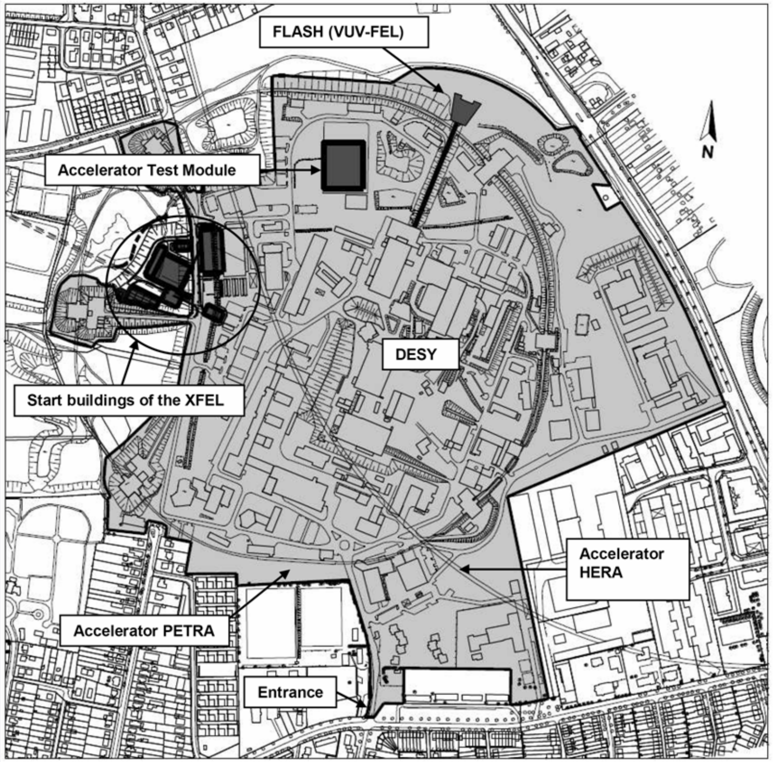
  'communicate' with spare RF stations
- **correct RF system parameters (feed forward tables) according to variable beam loading**

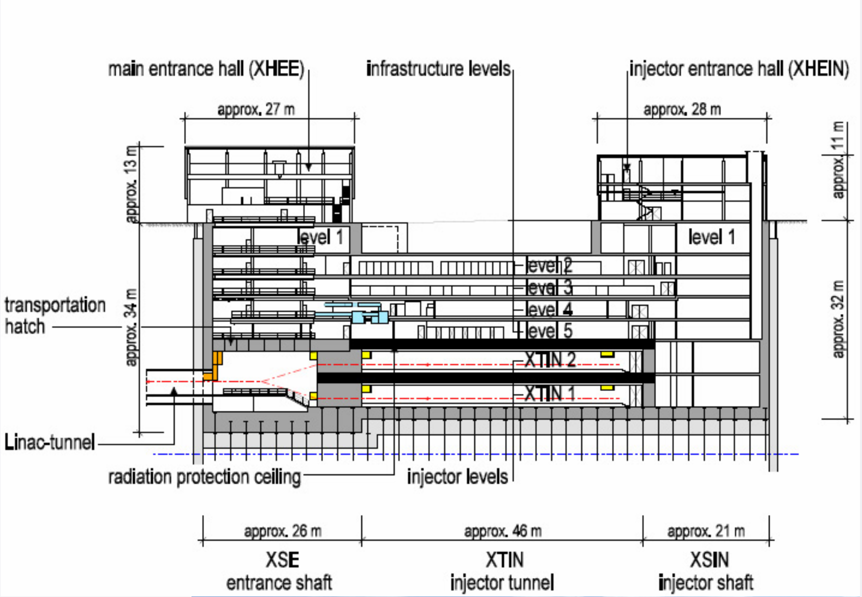
XFEL site in Hamburg/Schenefeld

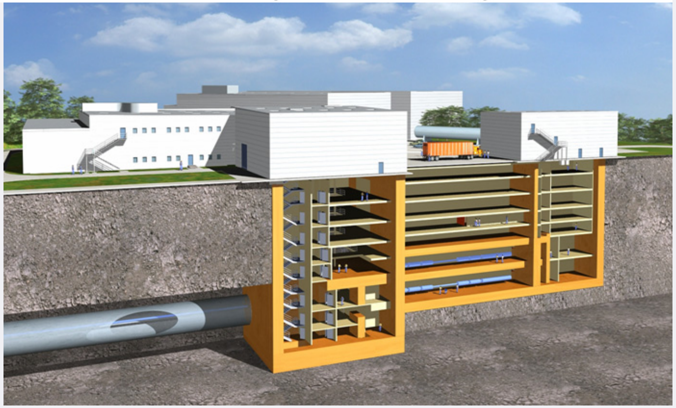
… after construction *(computer simulation)*



XFEL Buildings on the DESY Site



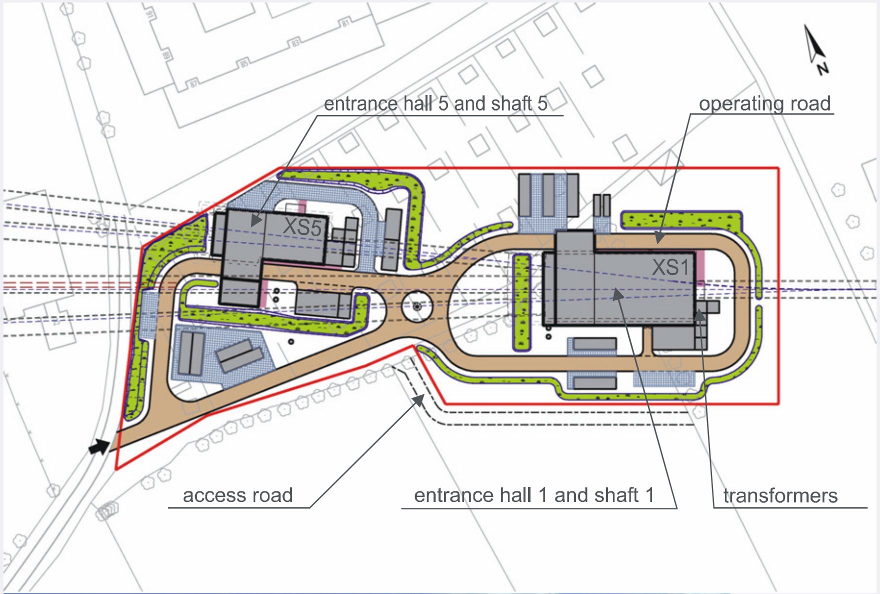


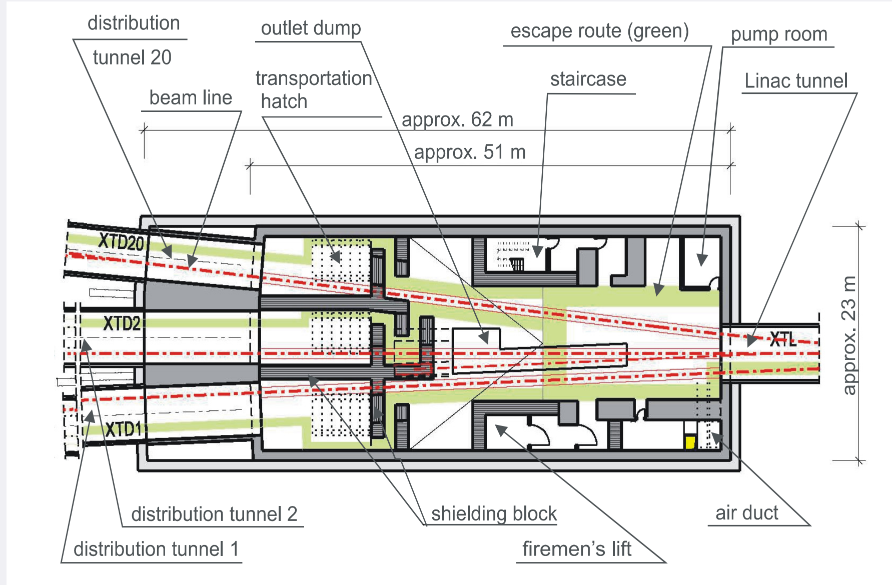


Ongoing call for tender for civil construction.

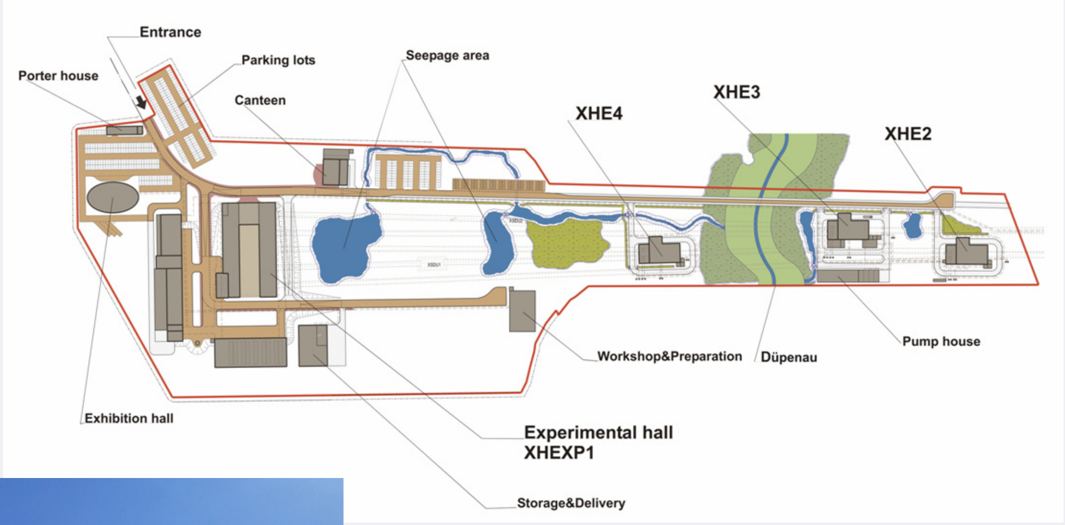
The XFEL injector is basically a copy of the TTF Linac.

XFEL Distribution Shaft (XSE)

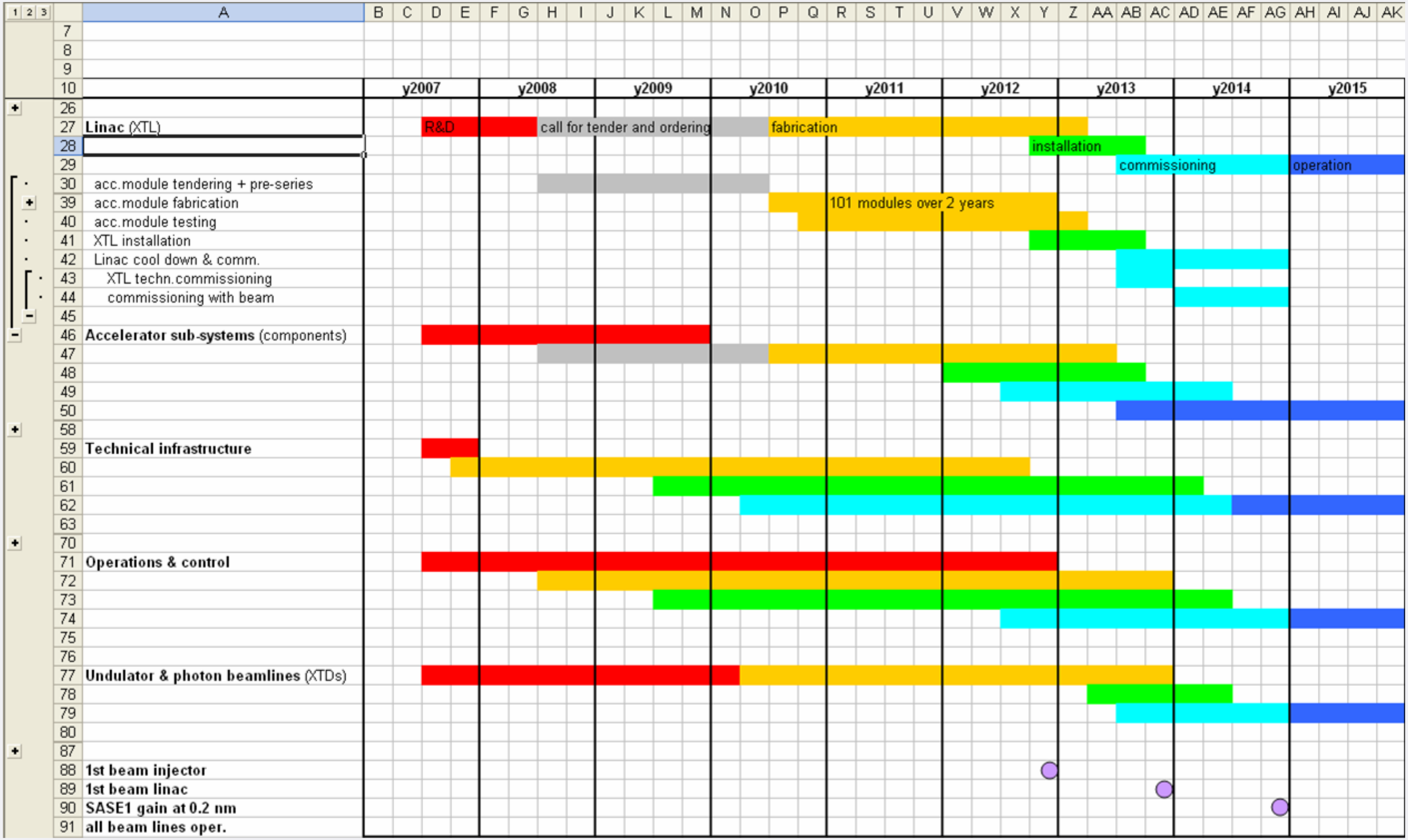




XFEL Experimental Hall



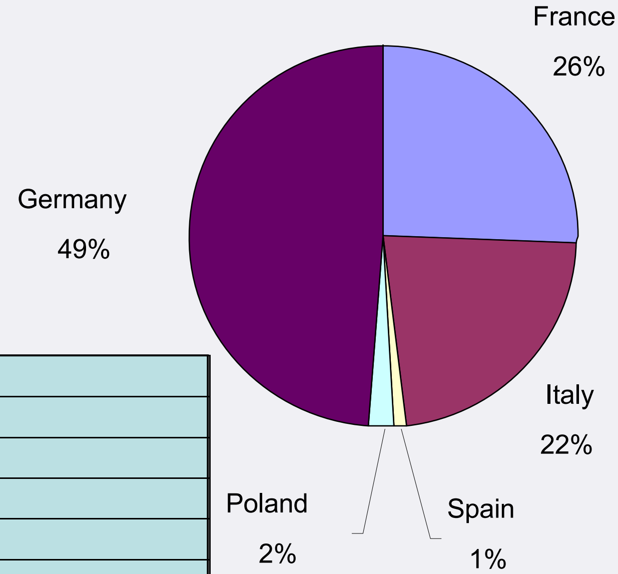
XFEL Schedule – First Beam Through Linac before End of 2013



Contributions to the XFEL Cold Linac

		Laboratory	Country	Invest / M€	FTE	FTE / M€
Accelerator Modules	**WP – 3**	CEA Saclay	France	60%		43%
		INFN	Italy	19%		29%
		DESY	Germany	21%		29%
	sum			***100%***		***100%***
Superconducting Cavities	**WP – 4**	INFN	Italy	50%		34%
		DESY	Germany	50%		66%
	sum			***100%***		***100%***
		Received from WP -9				
Power Couplers	**WP – 5**	LAL Orsay	France	73%		52%
		DESY	Germany	27%		48%
		or				
		LAL Orsay	France	99%		100%
		DESY	Germany	1%		0%
	sum			***100%***		***100%***
HOM Coupler / Pick-up	**WP – 6**	IPJ Swierk	Poland	100%		100%
	sum			***100%***		***100%***
Frequency Tuners	**WP – 7**	DESY	Germany	100%		100%
	sum			***100%***		***100%***
Cold Vacuum	**WP – 8**	DESY	Germany	100%		100%
	sum			***100%***		***100%***
Cavity String Assembly / Clean Room Quality Assurance	**WP – 9**	CEA Saclay	France	90%		51%
		DESY	Germany	10%		49%
		Transferred to WP -4				
	sum			***100%***		***100%***
Cold magnets	**WP - 11**	CIEMAT	Spain	56%		10%
		DESY	Germany	44%		90%
	sum			***100%***		***100%***

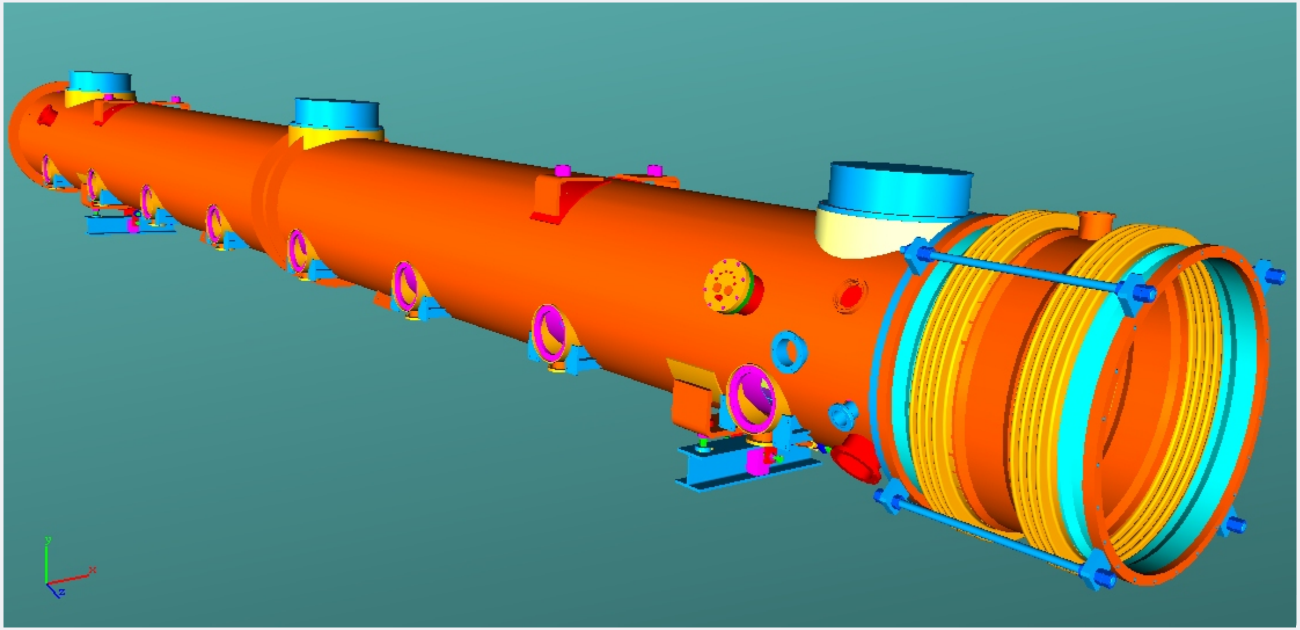
XFEL Cold Linac - Proposed Distribution of In-Kind Contributions



Laboratory	Invest / M€	FTE / M€	Sum / M€	
CEA Saclay				
LAL Orsay				
INFN				
CIEMAT				
DESY				
IPJ Swierk				
Sum France				25,4%
Sum Italy				22.7%
Sum Spain				1.1%
Sum Poland				2.1%
Sum Germany				48.7%
Sum WP 3-9 & 11	xxxxx	yyyyy	zzzzz	**100%**

Accelerator Modules

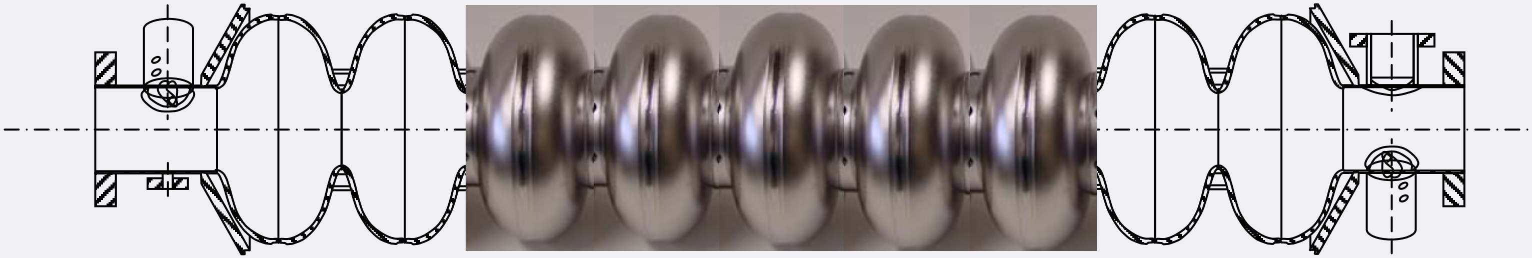
Invest		FTE	
60% CEA 19% INFN 21% DESY	Invest	FTE	43% CEA 29% INFN 29% DESY

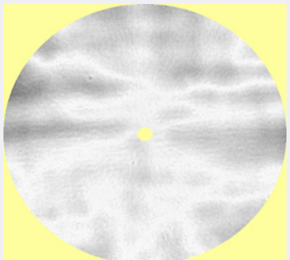
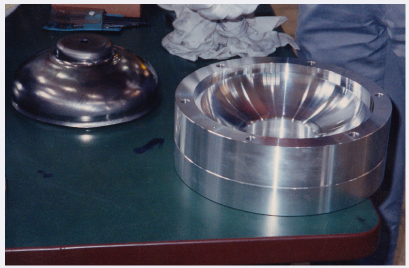


- Fabrication of cold masses (incl. outer vessel)
- module assembly w/o frequency tuner & power coupler; start with assembled string and finish with module installation
- weld connections
- alignment inside modules
- transportation of assembled accelerator modules
- material specifications, safety issues
- define processes for integration / assembly
- magnetic shielding / demagnetization
- sensors inside the accelerator modules
- pre-alignment of cavities and coupler position

Superconducting Cavities

50% INFN 50% DESY	Invest	FTE	34% INFN 66% DESY



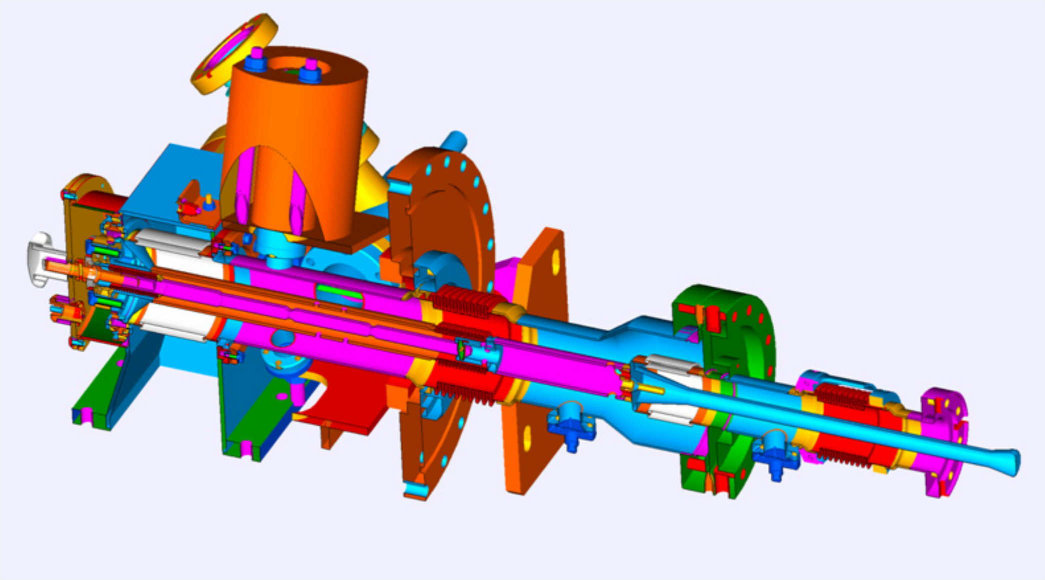
    

- Procurement of all niobium
- Scanning of NB sheets
- Complete mechanical fabrication of all cavities
- Surface treatment
- Consultant at start up of infrastructure and at full running production

- Data base setup and database running
- EDMS
- Helium vessel incl. Titanium parts (taken ove from WP-9)

Power Coupler

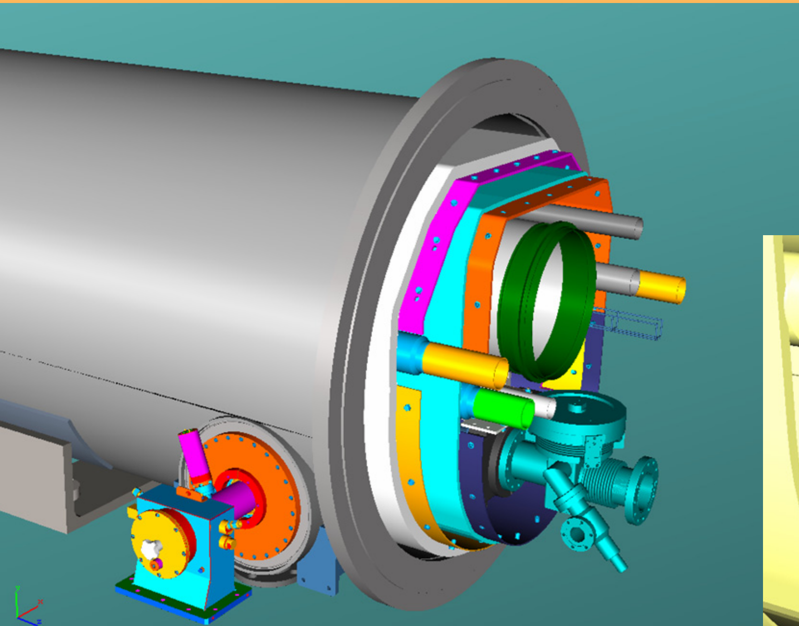
73% LAL 27% DESY	Invest	FTE	52% LAL 48% DESY

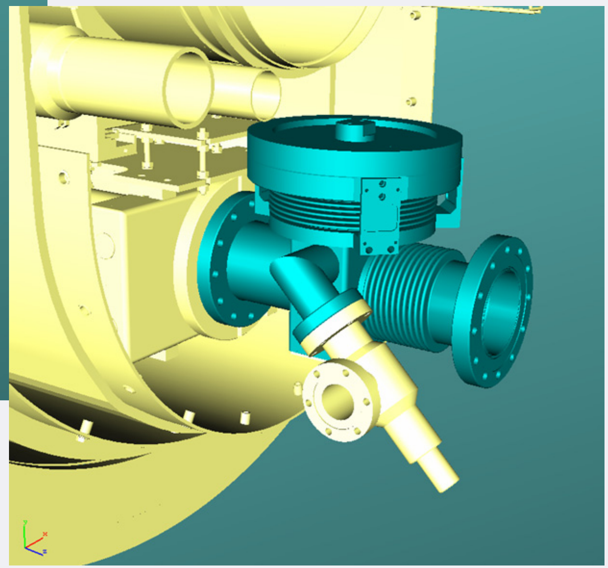


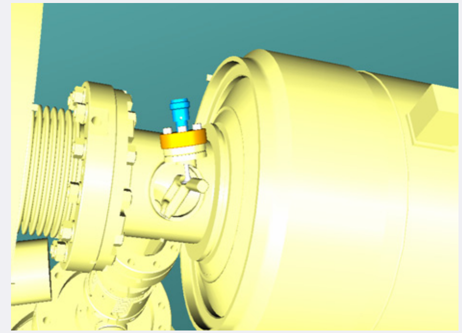
- Coupler production incl. project and industries follow-up
- Coupler conditioning
- Infrastructure required for coupler assembly and conditioning, i.e. clean room and modulator / klystron
- Technical interlock
- Tunnel installation / cabling of technical interlock
- Motor electronics

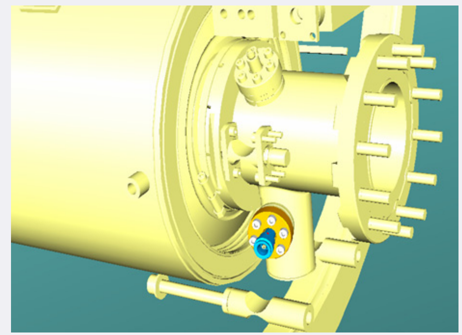
HOM Coupler / Pick-up

100% Swierk	Invest	FTE	100% Swierk





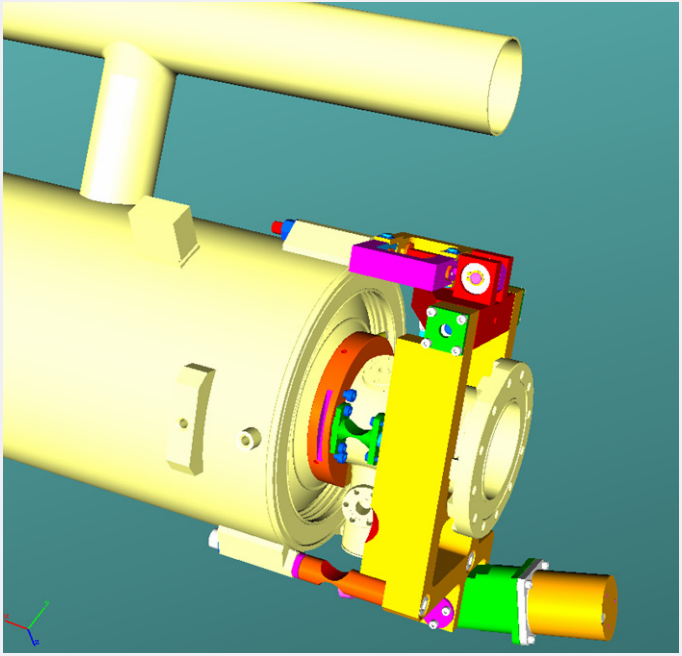


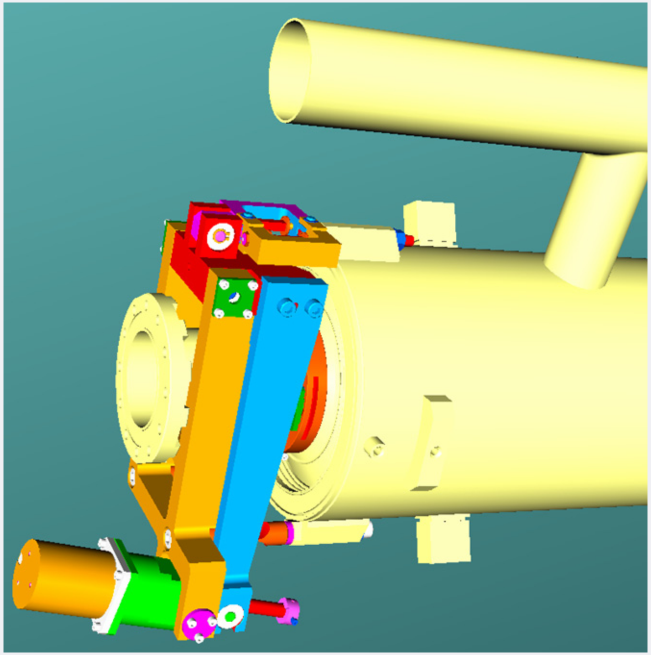


- Fabrication of HOM beam pipe absorbers
- HOM Pick-ups and cables

Frequency Tuners

100% DESY	Invest	FTE	100% DESY

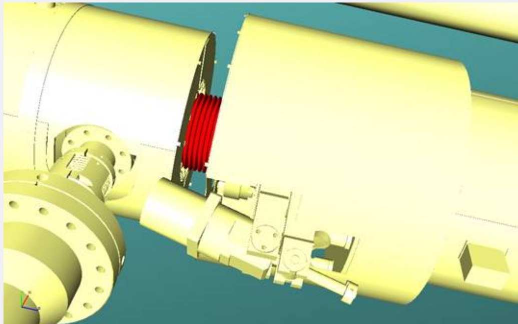


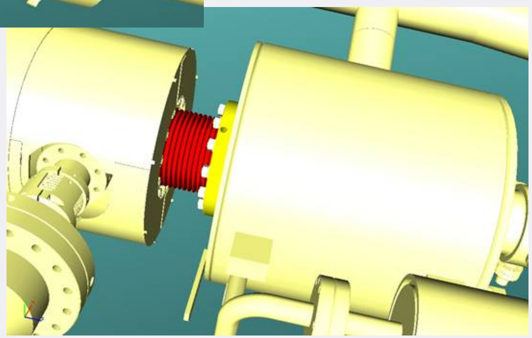


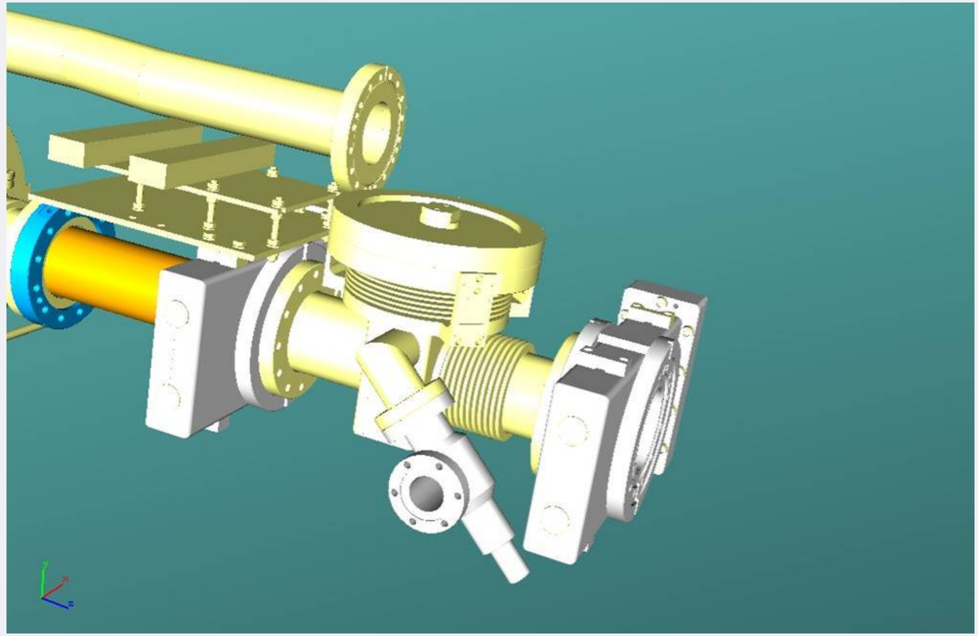
- procurement of motors, gear box, piezo actuators
- fabrication of mechanical tuner parts
- fabrication of drive unit (motor and piezo) electronics
- cabling
- survey of production

Cold Vacuum

Invest	FTE
100% DESY	100% DESY



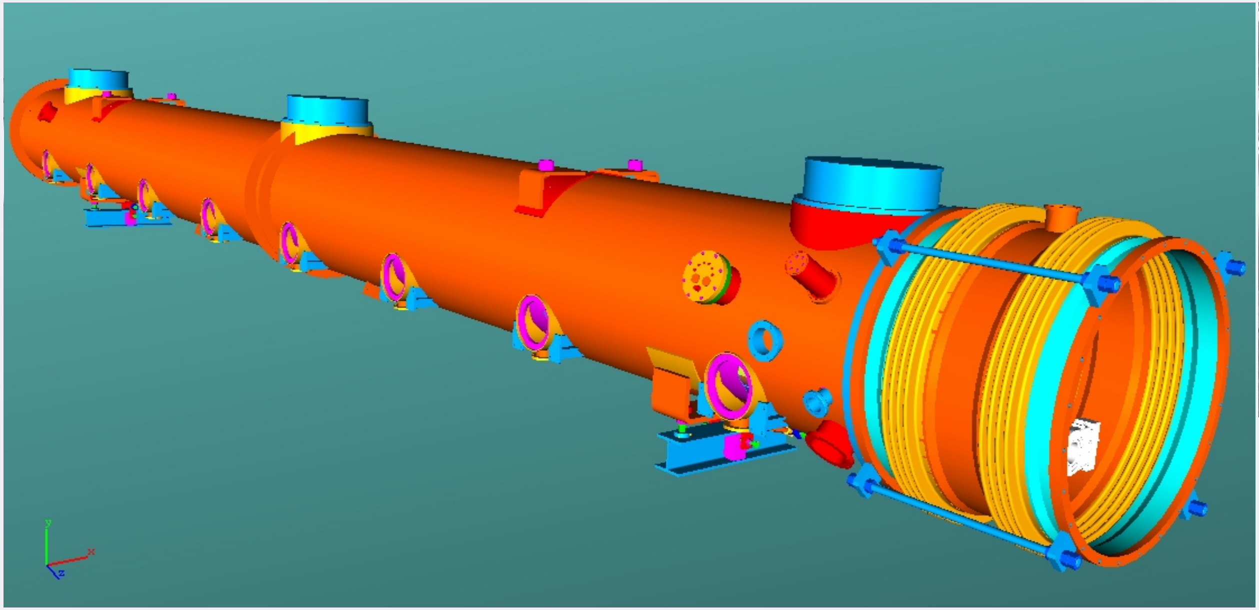




- procurement of all vacuum components within the cold linac, i.e.
  - bellows between cavities
  - cold manual valves at both ends of the cavity strings
  - valves in the module connection
  - isolation vacuum valves
  - ion and TSP pumps incl. power supplies/controllers
  - all vacuum components being part of the cryogenic connection boxes and of the cold-warm transitions
- vacuum components in the injector as well as bunch compressor sections (to be transferred to WP – 19)

Cavity String Assembly / Clean Room Quality Assurance

Invest		FTE	
90% CEA 10% DESY			51% CEA 49% DESY

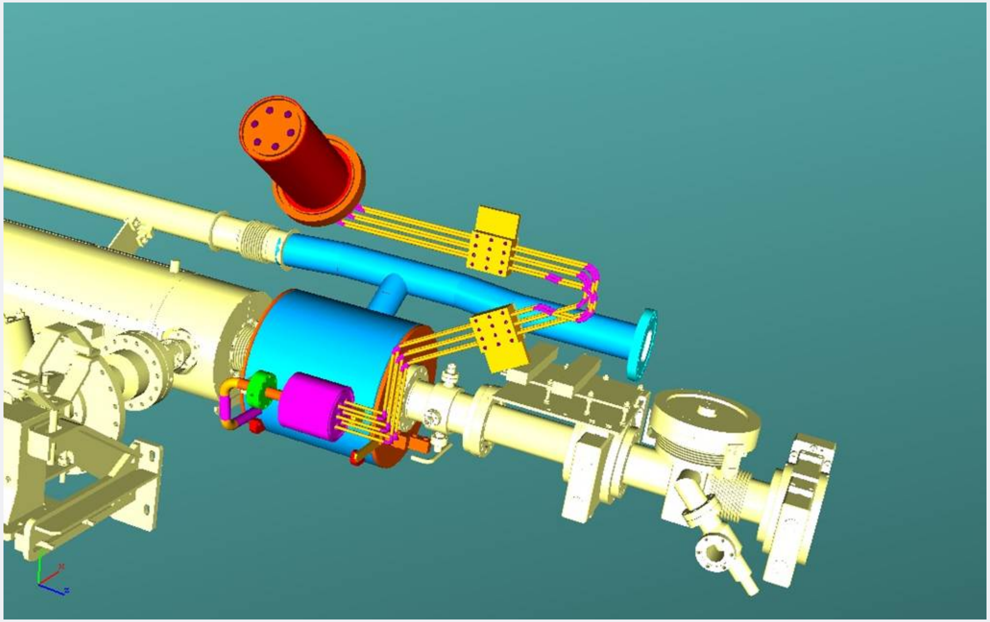


Module assembly see WP-3

- Helium vessel fabrication
- Titanium Tube and 2-phase line
- String assembly
- Knowledge transfer / consultant / training
- Database set-up and running / Quality control of infrastructure
- EDMS

Cold Magnets

	Invest	FTE	
56% CIEMAT 44% DESY			10% CIEMAT 90% DESY



- fabrication of 2K quadrupole package
- test of quadrupole package

Large Russian Contribution

WP1 RF System	BINP Novosibirsk
WP10 Module Test Facility	IHEP Protvino
WP12 Warm Magnets	NIIEFA St.Petersburg
WM13 Cryogenics	IHEP Protvino
WP14 Injector	JINR Dubna
WP17 Standard Beam Diagnostics	IHEP Protvino
WP18 Special beam Diagnostics	INR Troitsk
WP19 Warm Vacuum	BINP Novosibirsk
WP20 Beam Dump	IHEP Protvino
WP28 Control Systems	IHEP Protvino
WP33 Tunnel Installation	IHEP Protvino
WP34 Utilities	BINP Novosibirsk

WP21 Undulators
BINP Novosibirsk

WP24 Photon Diagnostics
PhTI St. Petersburg

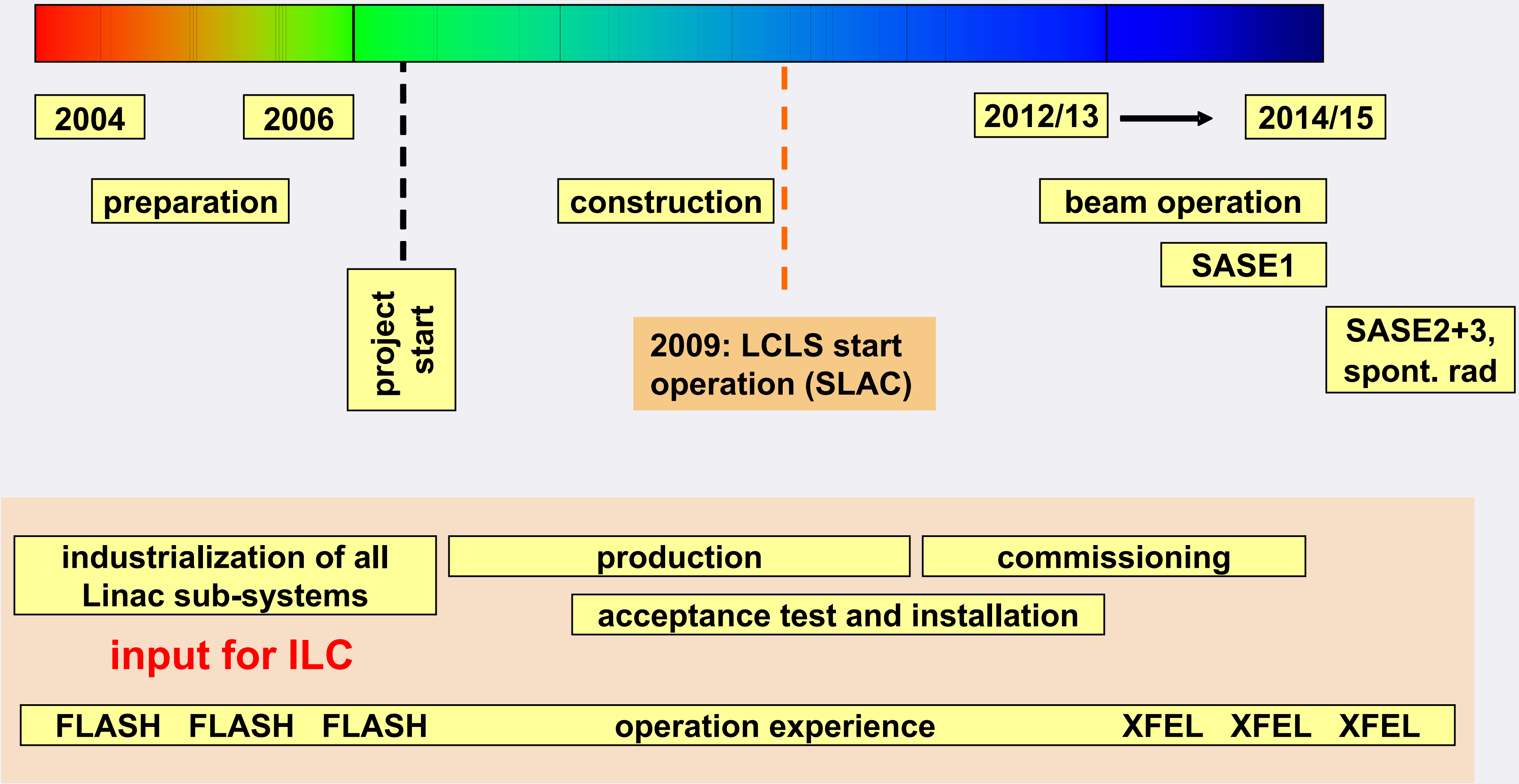
WP26 Detector Development
JINR Dubna

Some well know partners

&

a new management.

Summary

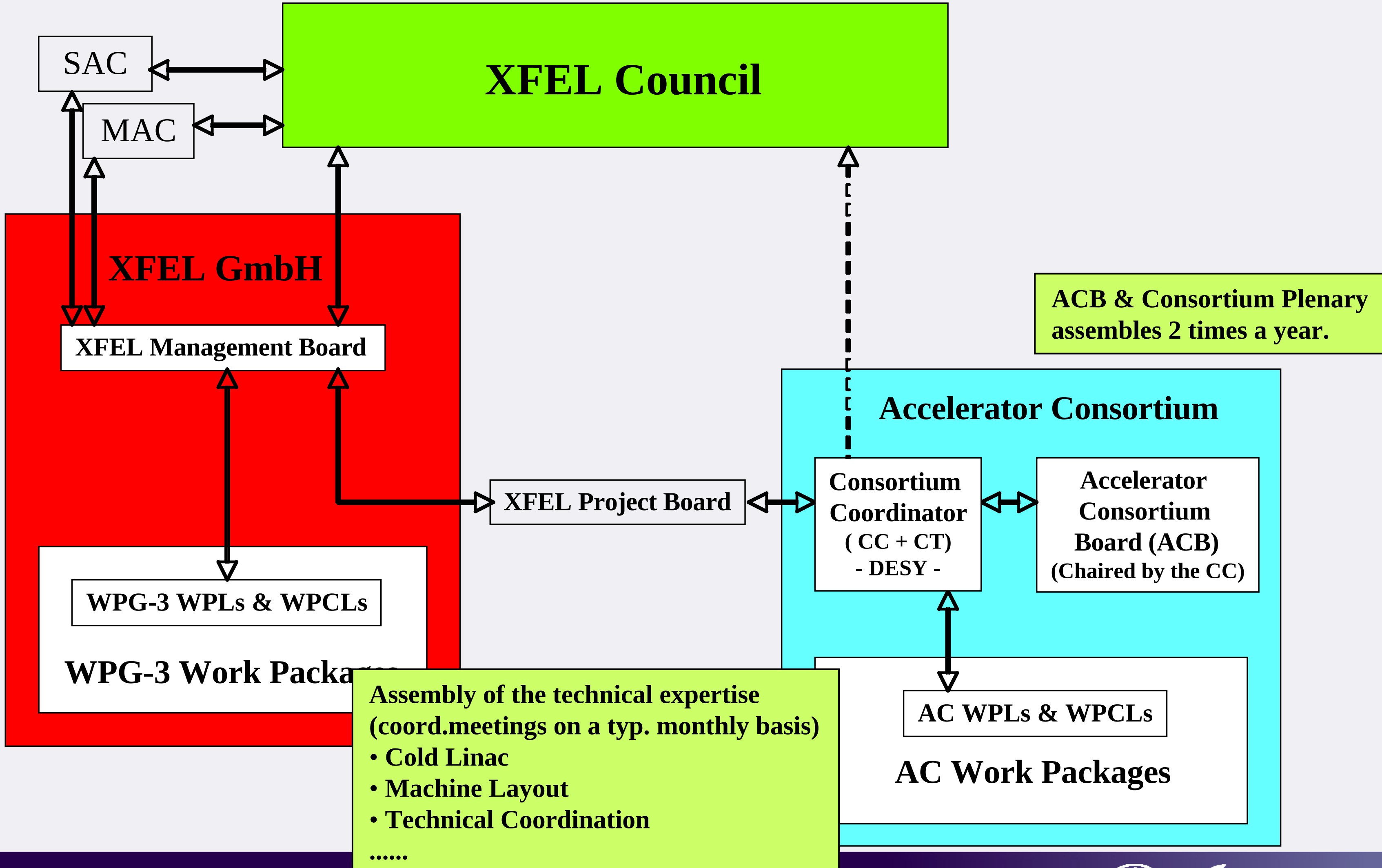

2004
2006
2012/13
2014/15
preparation
construction
beam operation
SASE1
project start
2009: LCLS start operation (SLAC)
SASE2+3, spont. rad
industrialization of all Linac sub-systems
production
commissioning
acceptance test and installation
input for ILC
FLASH FLASH FLASH
operation experience
XFEL XFEL XFEL

XFEL Consortium

Preamble

The XFEL Accelerator Consortium aims to operate a flat hierarchy, facilitating management and leadership and to apply the principle of subsidiarity.

XFEL Construction: Overall Organisation & Information Flow



Coordination Team Assistance for In-Kind Contribution Negotiations

XFEL GmbH
Has the overall project responsibility
-> Directly covered activities

Accelerator Consortium covered activities

Consortium Coordination -> CC + Coordination Team

- Cold Linac Coordinator
- Machine Layout Coordinator
- Technical Coordinator
- Project Office Leader

WPG1 - Cold Linac WPs
- WP-1: RF System
- WP-2: LLRF
- WP-3: Acc. Modules
- WP-4: S.C. Cavities
- WP-5: Power Coupler
- WP-6: HOM Cp&Pick-Up
- WP-7: Frequency Tuner
- WP-8: Cold Vacuum
- WP-9: Cav. String Assem
- WP-11: Cold Magnets
- WP-46: 3.9 GHz System

WPG2 - Acc. Sub-Sys WPs
- WP-12: Warm Magnets
- WP-14: Injector
- WP-15: BCion & S-to-E-S
- WP-16: Lattice & Dyn
- WP-17: Sta. e-Beam Diag.
- WP-18: Spe. e-Beam Diag.
- WP-19: Warm Vacuum
- WP-20: Beam Dumps

WPG3 - PBL WPs
- WP-71: Undulators
- WP-72: FEL Concepts
- WP-73: X-Ray Optics
- WP-74: X-Ray Diag.
- WP-75: X-Ray Det & Dev
- WP-76: DAQ & Controls
- WP-77: Exp. & Instr.
- WP-78: Optical Lasers
- WP-79 Sample Environ.

WPG4 - Contr. &Op. WPs
- WP-28: Acc. Control Sys
- WP-29: Operability
- WP-35: Radiation Safety
- WP-36: General Safety
- WP-38: Pers. Interlock
- WP-39: EMI

WPG55 - Infrastr. WPs
- WP-10: AMTF
- WP-13: Cryogenics
- WP-32: Survey and Align.
- WP-33: Tunnel Inst.
- WP-34: Utilities

Coordination Team Assistance for WP Activities & Integration

XFEL GmbH

Has the overall project responsibility

-> Directly covered activities

Accelerator Consortium covered activities

Consortium Coordination -> CC + Coordination Team (CT)

Cold Linac Coordinator	Machine Layout Coordinator	Technical Coordinator	Project Office Leader

WPG1 - Cold Linac WPs	WPG2 - Acc. Sub-Sys WPs	WPG3 - PBL WPs	WPG4 - Contr. &Op. WPs	WPG5 - Infrastr. WPs
WP-1: RF System	WP-12: Warm Magnets	WP-71: Undulators	WP-28: Acc. Control Sys	WP-10: AMTF
WP-2: LLRF	WP-14: Injector	WP-72: FEL Concepts	WP-29: Operability	WP-13: Cryogenics
WP-3: Acc. Modules	WP-15: BCion & S-to-E-S	WP-73: X-Ray Optics	WP-35: Radiation Safety	WP-32: Survey and Align.
WP-4: S.C. Cavities	WP-16: Lattice & Dyn	WP-74: X-Ray Diag.	WP-36: General Safety	WP-33: Tunnel Inst.
WP-5: Power Coupler	WP-17: Stan. Beam Diag.	WP-75: X-Ray Det & Dev	WP-38: Pers. Interlock	WP-34: Utilities
WP-6: HOM Cp&Pick-Up	WP-18: Spec. Beam Diag.	WP-76: DAQ & Controls	WP-39: EMI	
WP-7: Frequency Tuner	WP-19: Warm Vacuum	WP-77: Exp. & Instr.		
WP-8: Cold Vacuum	WP-20: Beam Dumps	WP-78: Optical Lasers		
WP-9: Cavity Str Assem		WP-79 Sample Environ.		
WP-11: Cold Magnets				
WP-46: 3.9 GHz System				

Consortium Coordination & Consortium Coordinator (CC)

The XFEL GmbH is going to mandate DESY to act on its behalf as coordinator of the Accelerator Consortium.

The general charges are:

- **Setting-up the Accelerator Consortium**
- **To manage and direct the construction and commissioning of the XFEL Accelerator Complex**
- **Liaising between the members of the XFEL Accelerator Consortium and the XFEL Company**
- **Implementing the guidelines defined by the XFEL GmbH and the ACB**

Therefore DESY has appointed a Consortium Coordinator (CC) and an assisting Coordination Team (CT), consisting of a:

- **Cold Linac Coordinator (CLC)**
- **Machine Layout Coordinator (MLC)**
- **Systems Integration & Technical Coordinator (TC)**
- **Project Office Leader (POL)**

The CT Members report directly to the CC.

The XFEL Management Board and the Consortium Coordinator with his Coordination Team form a Project Board, which meets regularly (in general weekly) to follow up the construction progress and to discuss problems.

Accelerator Consortium Board (ACB)

The Representatives of all XFEL Accelerator Consortium Members, the XFEL Management Board and the Consortium Coordinator form an "Accelerator Consortium Board", which meets at least twice a year to review the progress of the project and the interaction between the Parties, issues guidelines for the further collaboration and discuss any problems which may have arisen.

Composition

- 1 Representative per XFEL Accelerator Consortium Member
- The XFEL Management Board
- Consortium Coordination (CC + CT ex officio)

Chair

The Accelerator Consortium Board is chaired by the Consortium Coordinator

Functions

- Shall review the progress of the Accelerator Complex construction
- Shall review the interaction between the Accelerator Consortium Members
- Shall propose and approve actions and guidelines for the further collaboration
- Shall act as arbitration body for disputes between Accelerator Consortium Members
- Shall propose recovery plans to the XFEL Council to overcome project jeopardising problems or delays

Work Package (WP) & Work Package Leader (WPL)

The XFEL Accelerator Consortium organisation shall primarily maintain the Work Package structure defined in the XFEL Technical Design Report.

- **Work Packages are in charge to provide well-defined sub-systems in terms of Deliverables and Tasks.**
- **Work Packages shall be steered by a Work Package Leader and a Work Package Co-Leader.**

The Work Package Leaders and Co-Leaders are in charge for the specifications, design, manufacturing, assembly, tests and documentation of all Deliverables and Tasks subject to their Work Package Mandate. They are furthermore in charge for all organisational issues of their Work Package like schedule, sourcing of materials, manpower planning, implementing and executing safety measures, reviews, change management etc.

- **The charge extents until the Deliverables subject of the respective Work Package are handed over for higher level integration and all Tasks are finished, but still covers the technical commissioning after the Deliverables have been integrated and are formally handed over to another entity.**

The Work Package Leaders and Co-Leaders of Accelerator Consortium Work Packages are to be nominated by the Consortium Coordinator and are to be approved by the Accelerator Consortium Board.

All XFEL Accelerator Consortium Work Packages must follow the XFEL review and reporting schemes.

Mandates

Cold Linac Coordinator (CLC)

The CLC assists the CC being in charge of integrating the consortium activities which are subject of the Cold Linac and its directly associated sub-systems in terms of deliverables.

The CLC is in charge of overseeing the overall organisational issues, including schedules, sourcing of materials, reviews, cross-WP coordination needs etc. for his field of responsibility.

The CLC mandate extents until the deliverables are handed over for installation but still covers the technical commissioning after the deliverables have been installed.

The CLC reports directly to the CC.

Machine Layout Coordinator (MLC)

The MLC assists the CC being in charge of integrating the consortium activities which concern the layout and performance of the entire e- machine.

The MLC is in charge of overseeing the overall organisational issues associated with his field of responsibility.

The MLC mandate extents until all deliverables subject of the Accelerator Consortium mandate did pass the technical commissioning after integration into he facility.

The MLC reports directly to the CC.

Mandates

Technical Coordinator (TC)

The TC assists the CC being in charge of overseeing the overall systems integration and installation for the entire facility.

The TC is in charge of overseeing the overall organisational issues, including schedules, sourcing of materials, reviews, cross-WP coordination needs etc. for his field of responsibility.

The TC mandate extents until the deliverables are installed and still covers the technical commissioning

The TC reports directly to the CC.

Project Office Leader (PLO)

The Project Office Leader supports the Consortium Coordination by overseeing the reporting and scheduling systems, administrating the master schedule and providing figures and numbers about the overall project progress.

He reports directly to the CC.

Coordination Meetings

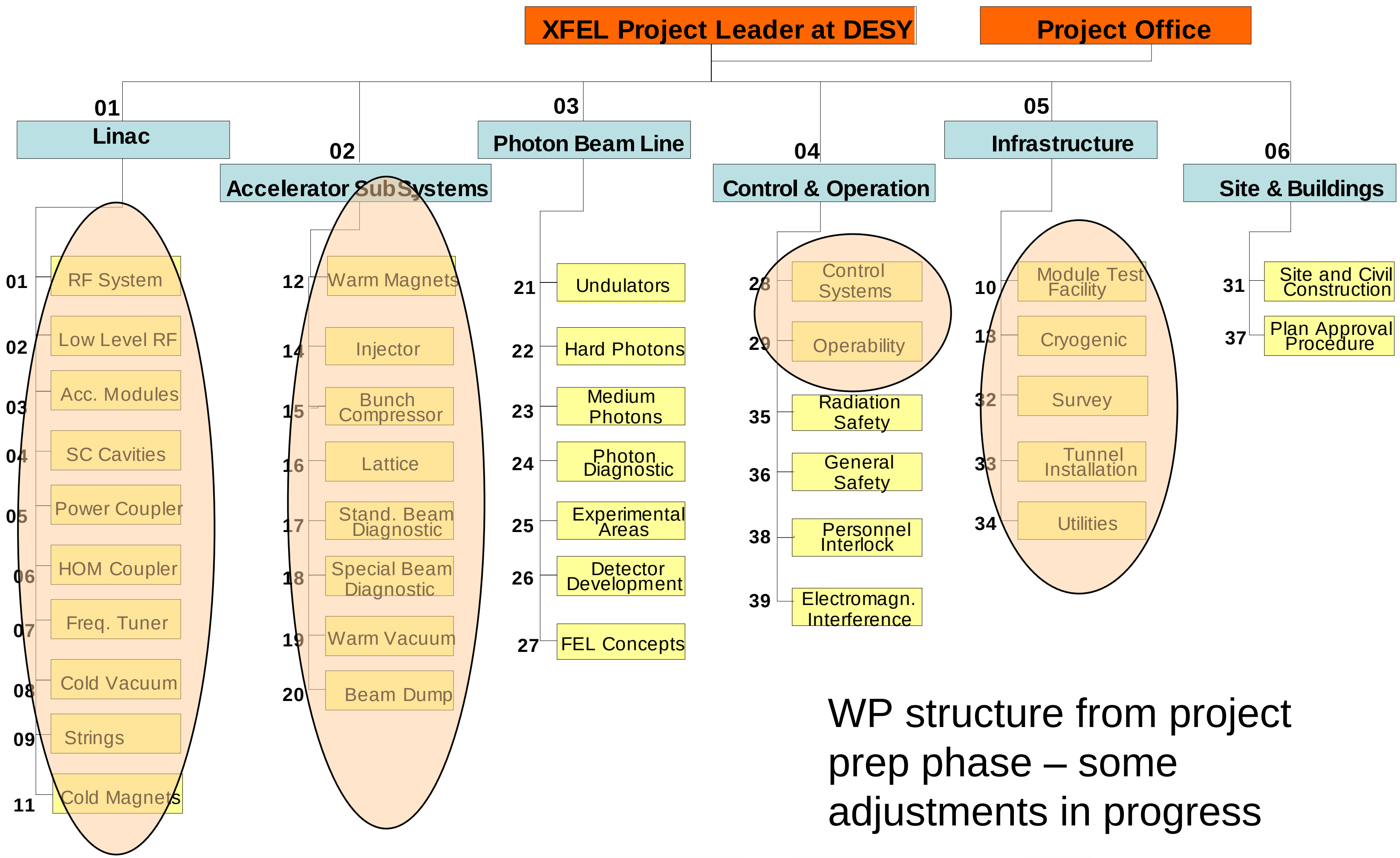
The technical expertise shall assemble in 3 Coordination Meetings (typ. monthly):

- **Cold Linac Coordination Meeting**
- **Machine Layout Coordination Meeting**
- **System Integration & Technical Coordination Meeting**

These meetings shall be the main information and discussion platforms for WP-spanning and/or project-wide technical issues.

Status of in kind contributions

Accelerator Consortium – “in-kind” contribution



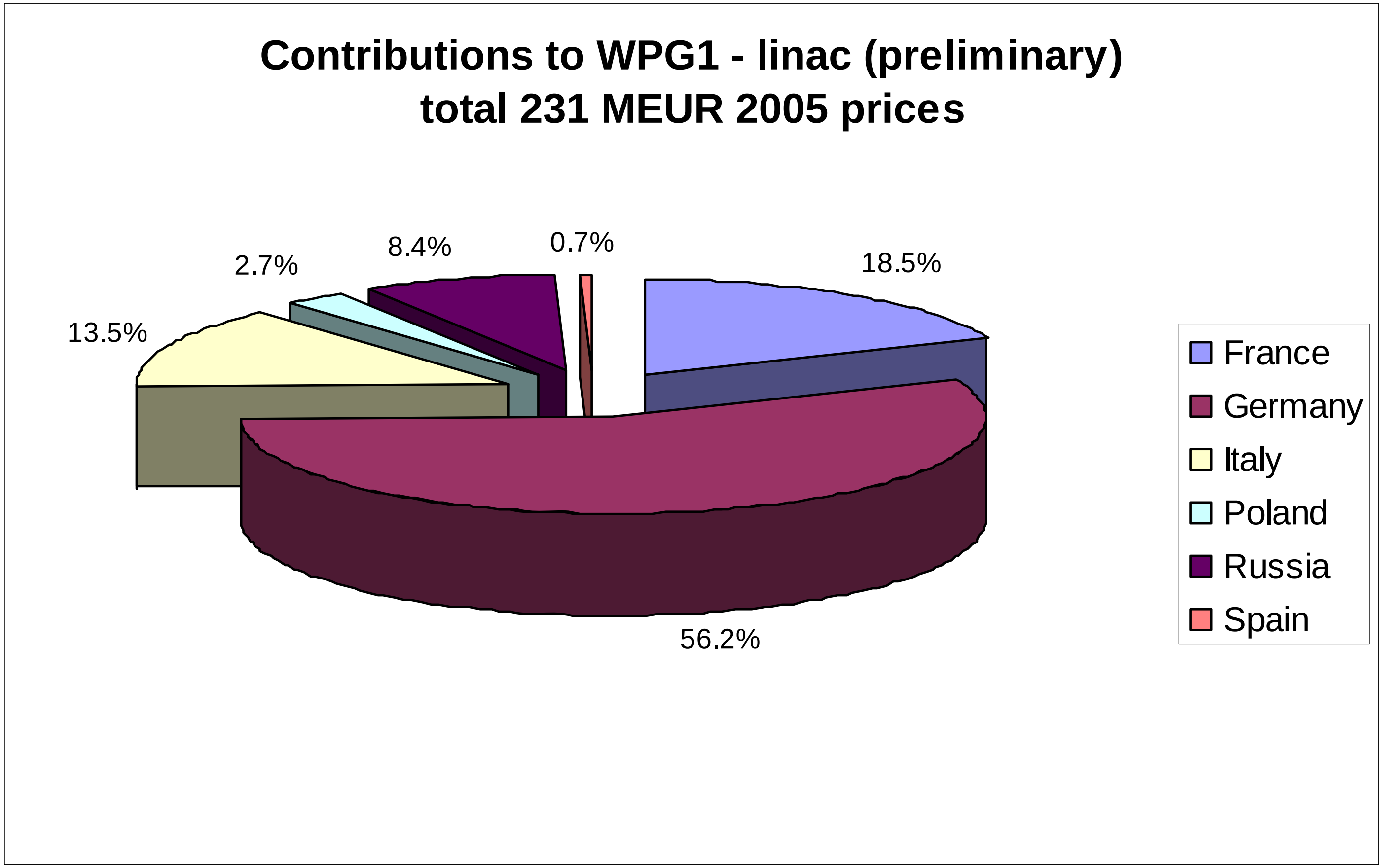
WP structure from project prep phase – some adjustments in progress

Activity on in-kind contributions

- 16 new EoI drafts received
- Discussions between EoI proposers and DESY (in its role as Consortium Coordinator & in-kind contributor)
  - Scope, specifications and feasibility of the contribution
  - Sharing of work and responsibilities
  - Cost & schedule aspects
  - Certification aspects

- Aim is to prepare joint proposals covering complete work packages
- Much progress, but still a lot to do…

WPG1 Linac (WPs 1-9 and 11)



WPG1 cont'd

- WP01-RF system
  - BINP/Novosibirsk & IHEP/Protvino waveguide system, BINP pulse transformers; DESY everything else
  - Questions regarding purchasing of certain components, sharing of work between BINP/IHEP, manpower from BINP/IHEP on DESY site for assembly/test/installation
  - Follow-up meetings scheduled (starting Jan. 20)
  - should finalise package by Q2/08 (most urgent: start pulse trafo prototype)

- WP02-LLRF system
  - Joint EoI DESY + Polish institutes presented at last IKRC
  - LLRF-ATCA Review meeting with external reviewers Dec 4, 2007 at DESY

LLRF-ATCA review comments *(slides by S. Simrock)*

- Focused on evaluation of an ATCA based LLRF system:
  - With demonstrated technical performance with beam at FLASH
  - With demonstrated operability by machine operators
  - Which serves as development platform for XFEL LLRF software
  - Which is close to what is needed for XFEL
  - Project time line: January – December 2008
- Covering all LLRF subsystems to be installed at FLASH
  - Master Oscillator, frequency distribution and timing
  - Downconverters, vector-modulators
  - Digital feedback hardware, piezo controller
  - Controller software, low and high level applications software
  - Automation

Note: This was not a review of the XFEL LLRF system although it covered many aspects.

LLRF-ATCA review comments *(slides by S. Simrock)*

- Hardware development quite advanced and detailed
- Software development less advanced and still requires significant work.
- Hardware and software development schedule very ambitious
- Some concerns with specific solutions (high signal density at AMC connector, signal integrity for routing from RTM module, placement of AMC connectors on both sides of carrier board)

LLRF-ATCA review comments *(slides by S. Simrock)*

- The change from R&D to production mode for the XFEL requires a change of mode of operation :
  - Senior personnel (responsible for workpackages) from collaboration partners must join the core team at DESY for a significant portion of their time (~6 months / year) and commit their participation for the duration of the project.
  - Collaboration partner must be involved in project management
  - Must commit to agreed schedule and deliverables
  - Need reasonable balance between obligations in LLRF project and boundary conditions at Universities
  - Intellectual property must be accessible to all collaboration partners

WPG1 cont'd

- WPs 3-9 & 11 "Cold Linac"
  - Joint proposal already evaluated by IKRC
  - 4th cold linac meeting scheduled Feb 4&5, 2008 in Milano
- EoIs not yet included:
  - Contribution IHEP/Beijing on cryomodules & cavities
    - Construction of module prototype launched, agreement with DESY to provide support with expertise, evaluate the prototype & if suitable equip with cavities etc. → decision on in-kind contribution Q4/08
    - Not clear yet how to proceed with cavity proposal, discuss with cold linac group
  - Contribution IHEP/Protvino on MLI blankets for cryomodules
    - Discuss at next cold linac meeting

WPG1 cont'd

- Contribution IFJ-PAN/Cracow (part of the Manpower EoI), regarding software/database, electrical & mechanical engineering, installation
  - Finalise discussion of manpower-sharing between DESY and IFJ (expect ~30 FTE from IPJ)
- Much technical & organisational work ongoing, just to name a few examples:
  - Industrial electropolishing for small series of cavities has started
  - Offers for cryomodule-prototypes from 5 companies received
  - Construction of cavity tuning machine for series production launched
  - Planning of assembly facility at Saclay and coupler processing at Orsay ongoing
  - Planning for module transport test HH→Paris→HH
  - Critical technical decisions identified, e.g. cavity test w/without He-tank? Alternative freq tuner? Where to do cleaning of components like quads, BPMs, etc. prior to string/module assembly?
  - How to organise purchasing for shared WPs? (Cavities, modules)

WPG2 Accelerator sub-systems

- WP12-warm magnets
  - EoI Efremov Inst./St. Petersburg includes ***all*** magnets
    - Very near complete proposal – need to resolve detail of DESY participation (especially precision measurements for high field quality bunch compressor dipoles) and competition with Swedish bid on quads/undulator sections (~11% of total bid value)
  - EoI MSL/Stockholm on quads for undulator sections
    - MSL has started work on high-precesion quad center fiducialisation in project prep phase
  - Possibility of 3rd bid for undulator quads from CIEMAT, as part of EoI for undulator intersections/assembly
- WP14-injector
  - EoI Uppsala Univ. (submitted to last IKRC) for laser heater
  - DESY intends to take main part of injector package
    - Close relation to work ongoing at PITZ/DESY-Zeuthen

WPG2 cont'd

- WP15-bunch compressor
  - 3rd harmonic (3.9 GHz) system to be extracted from WP14 and moved as new WP into WPG1-linac; contributed by DESY
- WP16-lattice & optics
  - Beam stabilisation system part of PSI EoI already presented to IKRC
  - EoI by Univ. Aarhus on beam distribution kicker systems – to be done jointly with DESY
    - Ongoing R&D work @DESY, need to specify sharing of work & cost
- WP17-standard beam diagnostics
  - BPM systems shared by DESY-PSI-Saclay
    - Basic agreement on which types/technology to use; question of how many/where cavity BMPs to be used
    - Need to finalise details of how to share work & cost – submit joint proposal

WPG2 cont’d

- EoI by IHEP/Protvino on beam profile and beam loss monitor systems
  - Discussion at an early state – need to follow up to determine scope of contribution and sharing of work, responsibilities and cost
- WP18-special beam diagnostics
  - EoI JINR/Dubna on optical replica synthesizers
    - Not part of the baseline design, therefore not an IKC unless design change is decided
    - Interesting potential applications beyond beam diagnostics (fs-synchronisation)
  - EoI INR/Troitsk on deflecting mode cavity bunch slice diagnostics *(“LOLA” device at FLASH)*
    - 1st discussions Nov/Dec 2007 - Question whether RF-system part is taken by INR (DESY could give tech/orga support but would prefer whole system responsibility & funding with INR)
    - Attractive possibility to prototype & use system at PITZ/DESY-Zeuthen

WPG2 cont'd

- WP19-warm vacuum
  - EoI BINP Novosibirsk
    - question of contributing certain components (e.g. pumps) for large sections of the system or contributing smaller sections entirely
    - Very constructive discussions started (Dec 07), will follow-up to shape joint proposal
- WP20-beam dump
  - EoI IHEP/Novosibirsk on beam dump systems
    - Very near final proposal, few questions regarding sharing of work on design, installation, etc

WPG4 control & operation

- WP28-control system
  - Proposal by DESY with integrated EoI by Stockholm Univ. on timing/clock system development and configuration system design work
    - Participation of Uni Stockholm limited to three years, extension of the contribution conceivable

WPG5 Infrastructure

- WP10-accelerator module test facility & WP13-cryogenics
  - Joint proposal DESY-BINP-IHEP-WUT, covers WP13 completely and includes all cryogenics components for WP10
  - Details → presentation B. Petersen
- WP10-AMTF
  - EoI IFJ-PAN Cracow on manpower
    - Approx. 100 FTE (scientist/engineer/technician) to build & (mainly) operate the test facility
    - Very near finalised proposal, few details regarding sharing of work, schedule for starting the participation
- WP33-tunnel installation
  - EoI initially submitted by IHEP/Protvino, but recent agreement that INR/Troitsk will join
  - Discussions at an early stage, need to follow-up to determine scope, sharing of work & cost, IHEP/INR manpower at XFEL site during installation?, etc.

WPG5 cont'd

- WP34-utilities
  - EoI CIEMAT on s.c. (linac) quad power supplies
  - EoI BINP on warm magnet power supplies
    - Initially expressed boundary condition <1kW per p.s., seems to be removed (?)
    - DESY prefers solution where standardised digital regulation/control is contributed by DESY – need to discuss with partners
    - Delivery of devices only or participation in installation & technical commissioning?

Next steps

- There is still plenty of work necessary to detail EoIs towards proposals in ~final shape
- Some partners need to do cost-checks and negotiations with funding agencies
- Towards setting up the full Consortium:
  - Establish “Accelerator Executive Board”
  - Internationalise WP leadership
  - In-kind proposals → Accelerator Construction Agreement (signed and binding document) between Consortium members and XFEL company
  - Organise 1st General Consortium Meeting (tentatively late spring/08)

Next steps cont'd

- Issue to be addressed:
  - Value of in-kind contribution is fixed according to budget book in year 2005 prices
  - In-kind contributors handle deviations due to general price index & unavoidable uncertainties at the time of cost evaluation
  - There are exceptional cases where budget book value is "unfair":
    - Technically necessary design changes (not changing scope of project)
    - Large impact of raw material price escalation
    - (obvious mistakes in the budget book – if any)
  - Two (maybe more?) ways to handle exceptions
    - Access to risk budget (included in TDR!) as a "common fund" held by the XFEL company
    - If partner can provide additional funding, value of this WP needs adjustment to properly account the share in the project

Conclusion

- Remarkable progress on our way to put together the XFEL Accelerator Consortium – thanks to the constructive engagement of the colleagues from all partner labs and of my co-workers at DESY!

Installation workflow

XFEL Installation

2 Main Problems

i) Very large facility

ii) Start of civil constructions is delaying more and more

Main Goal

Meet “Firsts” dates as scheduled in TDR

- 1^{st} beam in Injector -> mid 2012
- 1^{st} beam in Linac -> mid 2013
- 1^{st} SASE(1) at 0. 2 nm -> mid 2014
- All beam lines oper. -> end 2015

Strategy

Installation work must be highly parallelised

-> Charge: compensate delayed civil construction start

No time must be lost in design, production, tests ... of components

-> Does not depend on civil construction start

No time must be lost due to stupidities

-> Requires excellent detail planning, serious checks of delivered material, early identification and communication of problems, fast decisions

XTL Installation - Workflow

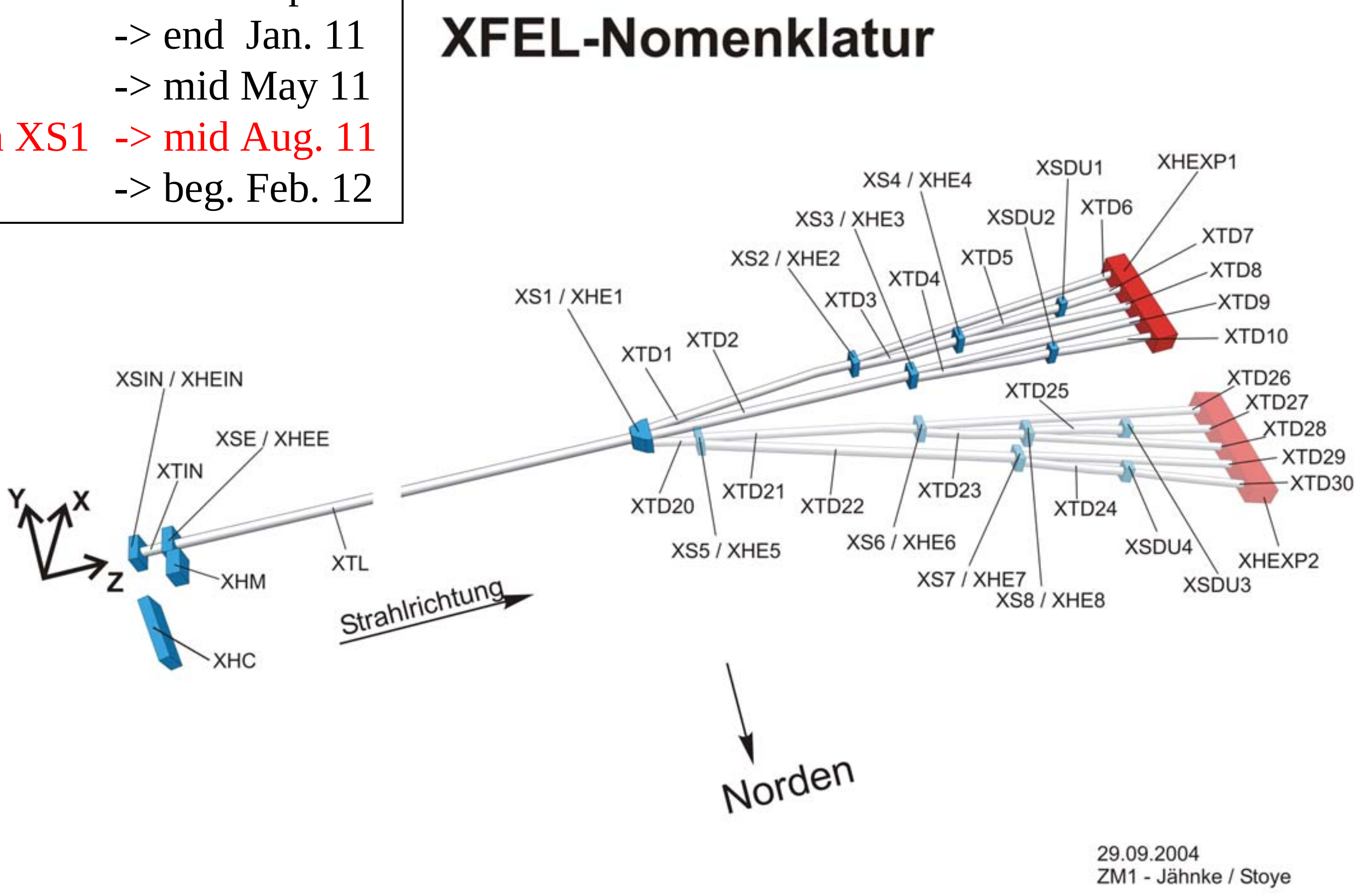
Important 'Ready-for-Installation' Dates

--> Assumption: receive GO for tendering in January 07

• Cryo Hall	-> beg. Jul. 09
• Modulator Hall	-> beg. Jan. 10
• XTIN via XSE	-> mid Jul. 10
• XTL via XSE	-> beg. Aug. 10
• XTIN via XSIN	-> end Sep. 10
• XTD1 via XS2	-> end Jan. 11
• XTD3 via XS4	-> mid May 11
• XTL, XTD1 & XTD2 via XS1	-> mid Aug. 11
• XTD2 via XS3	-> beg. Feb. 12

XTL Primary Installation:
ca. 57 weeks ≈> beg. Aug. 10 -> mid Sep. 11

XTL Machine Installation:
At least 45 weeks ≈> mid Sep. 11 -> mid Aug. 12



T. Hott, 11 Oct. 06

Availability analysis

Contents

- Introduction and purpose of studies
- The availability simulation
- Wake up ILC people
- What was modeled (important assumptions)
- Some results
- Conclusions

Introduction

- Availsim is a Monte Carlo simulation developed over several years for linear collider studies.
- Given a component list and MTBFs and MTTRs and degradations it simulates the running and repairing of an accelerator.
- It can be used as a tool to compare designs and set requirements on redundancies and MTBFs.
- It has now been applied to the XFEL.

Why a simulation?

- We chose to go with a simulation instead of a spreadsheet calculation for the following reasons:
  - Including tuning and recovery times in a spreadsheet calculation is difficult.
  - Fixing many things at once (during an access) is also difficult to put in a simple spreadsheet formula.
  - If later, one wants to more carefully model luminosity degradation on recovery from downtimes a simulation is simpler
  - A disadvantage of a simulation is its use of random numbers so one needs high enough statistics to get a meaningful answer. This is particularly a concern if one wants to compare two slightly different cases.
    - Random number seeds are handled in a way to allow meaningful comparisons of similar cases.
    - A 20 year simulation which gives good enough statistics takes 90 seconds on my laptop

The Simulation includes:

1. Effects of redundancy such as 21 DR kickers where only 20 are needed or the large energy overhead in the main linac
2. Some repairs require accelerator tunnel access, others can’t be made without killing the beam and others can be done hot.
3. Time for radiation to cool down before accessing the tunnel
4. Time to lock up the tunnel and turn on and standardize power supplies
5. Recovery time after a down time is proportional to the length of time a part of the accelerator has had no beam. Recovery starts at the injectors and proceeds downstream.
6. Manpower to make repairs can be limited.

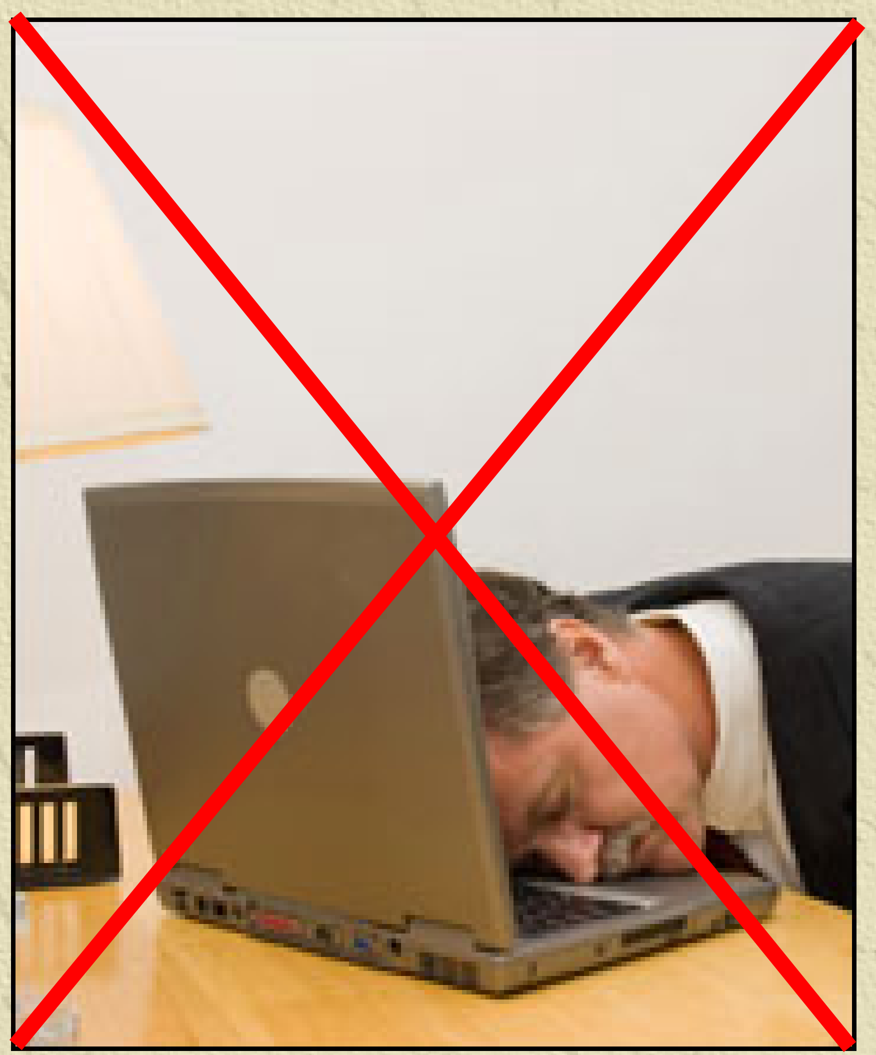
The Simulation includes:

7. Opportunistic Machine Development (MD) is done when part of the accelerator is down but beam is available elsewhere for more than 2 hours.
8. MD is scheduled to reach a goal of 1 - 2% in each region of the accelerator.
9. All regions are modeled in detail down to the level of magnets, power supplies, power supply controllers, vacuum valves, BPMs …
10. The cryoplants and AC power distribution are not modelled in detail.
11. Non-hot maintenance is only done when the accelerator is broken. Extra non-essential repairs are done at that time though. Repairs that give the most bang for the buck are done first.

The Simulation includes:

12. PPS zones are handled properly e.g. can access linac when beam is in the injector. It assumes there is a tuneup dump at the end of each region.
13. Kludge repairs can be done to ameliorate a problem that otherwise would take too long to repair. Examples: Tune around a bad quad in the cold linac or disconnect the input to a cold power coupler that is breaking down.
14. During the long (1 month) shutdown, all devices with long MTTR's get repaired.

Wake Up ILC people



ILC – XFEL – SyncLight differences

	ILC	XFEL	SyncLight
Expt. Duration	years	week	shift
Care about	int lum	unsched downs	unsched downs
Allowed unsched downtime (%)	25	10 (e- only)	5
Budgeted unsched downtime (%)	15	7 (e- only)	
Downtime held as Contingency %	10	3	
Scheduled maintenance days	none	2 wks 8+4	
Run length (months)	9	11	
Num. of components (thousands)	250	17	
Cost (accel+expts) ($B)	7.6	1.4	
cool down time (minutes)	60	15	
access recovery time (minutes)	60	30	

Scheduled Maintenance Days

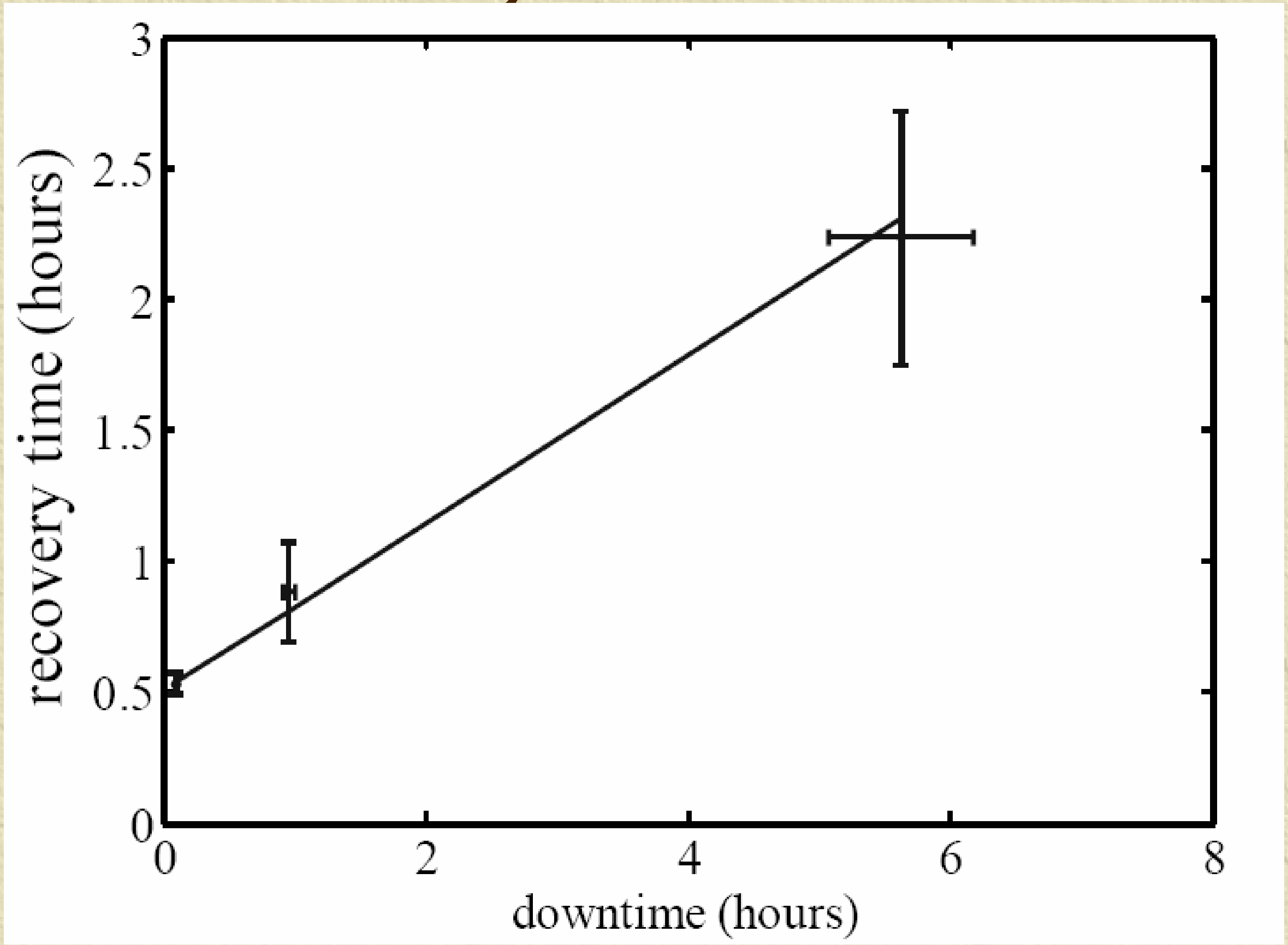
- New feature added for XFEL
- Regular shutdown for repairs/maintenance
- Counts as scheduled downtime, not unscheduled. Better for short term users.
- All repairs which can be completed with available manpower in available time are done. Most bang for buck first.
- Maintenance items (e.g. cleaning filters) which don't break things are not simulated.
- If recovery is longer than scheduled, extra is unscheduled down.
- If recovery is > 2 hours early, opportunistic MD is done.
- If we were down at beginning of maintenance day, remaining down is changed to scheduled.

Mined data from old accelerators

Component	MTBF (hr)	MTTR (hr)	comment
Water cooled magnet	1,000,000	8	Average from SLC. There have been magnet families with MTBF > 13,000,000
Air cooled magnets	10,000,000	2	SLC
Super conducting magnet	10,000,000	472	MTBF given is 10 times that of Tevatron dipole magnet as the SC quads in ILC are much lower current. We assumed a failed SC quad would be tuned around in 2 hrs as a kludge repair
Kicker pulsar	10,000	2	SLC
Magnet Power supplies	50,000	2 or 4	SLAC and FNAL average. The larger MTTR is for large not easily replaceable supplies
Electronics modules	100,000	1	This is a crude average over many types of electronics modules
Water flow switch	250,000	1	SLAC
Movable collimators and stoppers and valves	100,000	8	SLAC
DR klystron	30,000	8	SLAC
Linac Modulator	50,000	4	SLAC

MTBF data for accelerator components is scarce and varies widely

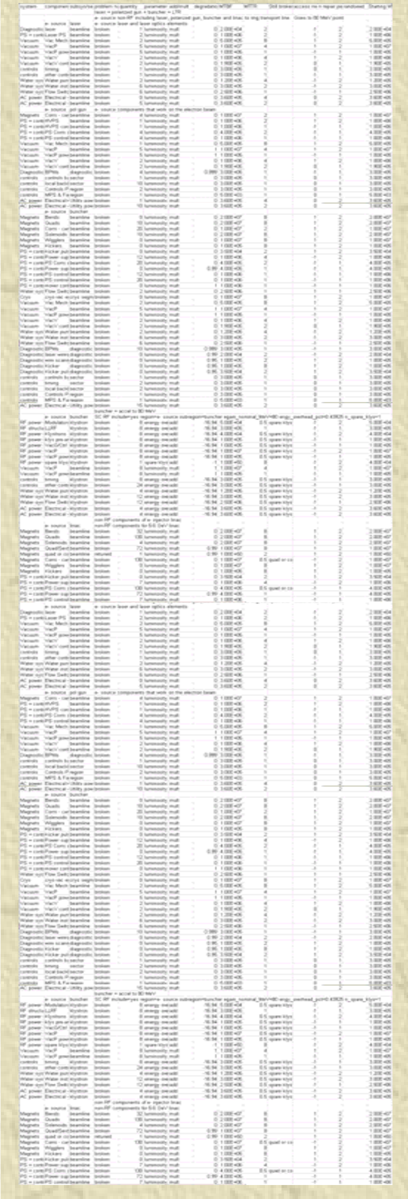
Recovery Time for PEP-II

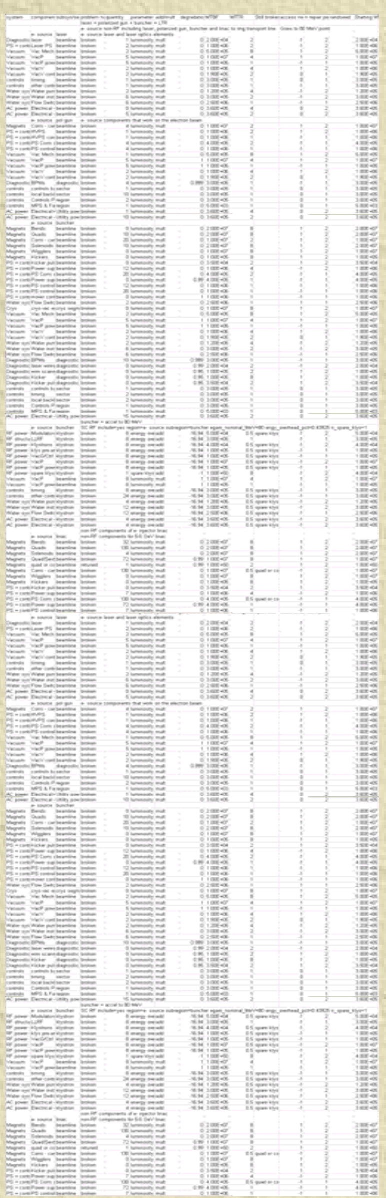


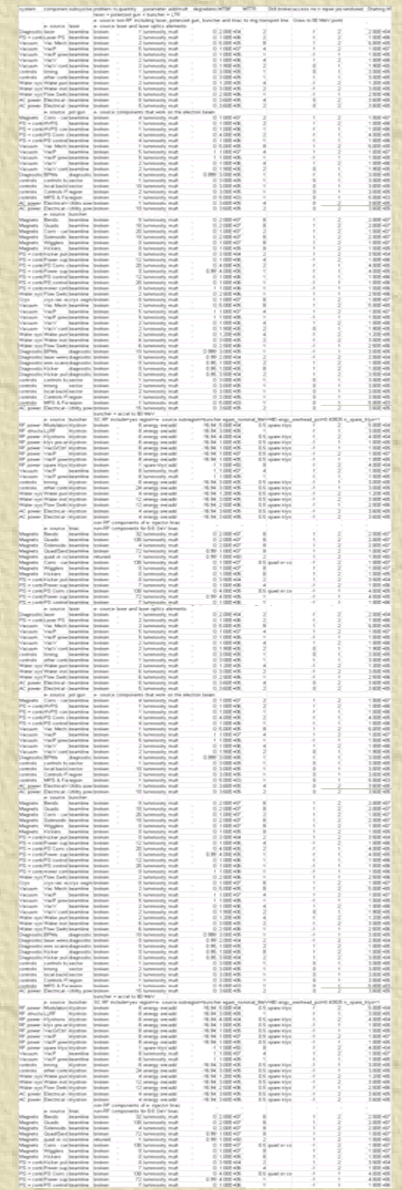
List of sub-decks

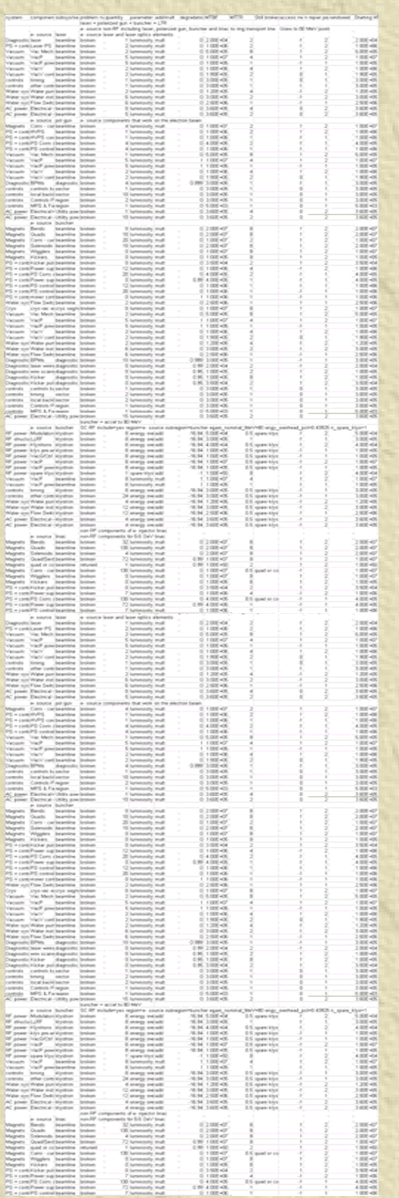
sheet	include	region	subregion	egain_nominal_MeV	ncavities_section	n_spare_klys	description
	injector 1						I1 + I1D
RF gun	yes	injector 1	RF gun		1	0	RF gun components including laser and klystron
inj	yes	injector 1	linac				non SCRF components of e- injector linac and dump
cryomodule	yes	injector 1	linac	130	8	0	SCRF components of e- injector linac
	compressor 1						L1+B1+B1D
compressor 1	yes	compressor 1					non RF compressor 1 hardware
cryomodule	yes	compressor 1	linac	370	32	0	RF for L1 in front of compressor 1
	compressor 2						L2+B2+B2D
compressor 2	yes	compressor 2					non RF compressor 2 hardware
cryomodule	yes	compressor 2	linac	1,500	96	0	RF for L1 in front of compressor 1
	main linac						L3
main linac	yes	main linac					main linac
cryomodule	yes	main linac		18,000	800	0	RF for main e- linac
	collimation						CL+TL+TLD+T1
collimation	yes	main linac					Collimation, transport, dump
	SASE 1						SASE 1 + SASE 3 = T2 + SA1 + T4 + SA3 + T4D
SASE 1	yes	SASE 1					Collimation, transport, dump
	SASE 2						SASE2 + U1 + U2 = SA2 + T3 + UN1 + T5 + UN2 + T5D
SASE 2	yes	SASE 2					Collimation, transport, dump

Full list of Components









system	componen	subsys/se	problem na	quantity	parameter	add/mult	degradatio	MTBF	MTTR	Still broken	access ne	n repair pe	randseed	Starting M
			laser + polarized gun + buncher + LTR											
			e- source non-RF including laser, polarized gun, buncher and linac to ring transport line. Goes to 80 MeV point.											
	e- source	laser	e- source laser and laser optics elements											
Diagnostic	laser	beamline	broken	1	luminosity	mult	0	2.00E+04	2		-1	2		2.00E+04
PS + conti	Laser PS	beamline	broken	2	luminosity	mult	0	1.00E+06	2		-1	2		1.00E+06
Vacuum	Vac Mech	beamline	broken	2	luminosity	mult	0	5.00E+05	8		1	2		5.00E+05
Vacuum	VacP	beamline	broken	5	luminosity	mult	0	1.00E+07	4		1	2		1.00E+07
Vacuum	VacP pow	beamline	broken	5	luminosity	mult	0	1.00E+05	1		-1	1		1.00E+05
Vacuum	VacV	beamline	broken	2	luminosity	mult	0	1.00E+06	4		1	2		1.00E+06
Vacuum	VacV cont	beamline	broken	2	luminosity	mult	0	1.90E+05	2		0	1		1.90E+05
controls	timing	beamline	broken	1	luminosity	mult	0	3.00E+05	1		0	1		3.00E+05
controls	other contr	beamline	broken	1	luminosity	mult	0	3.00E+05	1		-1	1		3.00E+05
Water sys	Water pum	beamline	broken	2	luminosity	mult	0	1.20E+05	4		-1	2		1.20E+05
Water sys	Water inst	beamline	broken	6	luminosity	mult	0	3.00E+05	2		-1	2		3.00E+05
Water sys	Flow Switc	beamline	broken	6	luminosity	mult	0	2.50E+06	1		-1	1		2.50E+06
AC power	Electrical -	beamline	broken	0	luminosity	mult	0	3.60E+05	4		0	2		3.60E+05
AC power	Electrical -	beamline	broken	5	luminosity	mult	0	3.60E+05	2		0	2		3.60E+05
	e- source	pol gun	e- source components that work on the electron beam											
Magnets	Corrs - car	beamline	broken	4	luminosity	mult	0	1.00E+07	2		1	2		1.00E+07
PS + conti	HVPS	beamline	broken	1	luminosity	mult	0	1.00E+06	2		1	2		1.00E+06
PS + conti	HVPS con	beamline	broken	1	luminosity	mult	0	1.00E+06	1		-1	1		1.00E+06
PS + conti	PS Corrs c	beamline	broken	4	luminosity	mult	0	4.00E+05	2		-1	1		4.00E+05
PS + conti	PS control	beamline	broken	4	luminosity	mult	0	1.00E+06	1		-1	1		1.00E+06
Vacuum	Vac Mech	beamline	broken	1	luminosity	mult	0	5.00E+05	8		1	2		5.00E+05
Vacuum	VacP	beamline	broken	5	luminosity	mult	1	1.00E+07	4		1	2		1.00E+07
Vacuum	VacP pow	beamline	broken	5	luminosity	mult	1	1.00E+05	1		-1	1		1.00E+05
Vacuum	VacV	beamline	broken	2	luminosity	mult	0	1.00E+06	4		1	2		1.00E+06
Vacuum	VacV cont	beamline	broken	2	luminosity	mult	0	1.90E+05	2		0	1		1.90E+05
Diagnostic	BPMs	diagnostic	broken	4	luminosity	mult	0.999	3.00E+05	1		-1	1		3.00E+05
controls	controls ba	sector	broken	1	luminosity	mult	0	3.00E+05	1		0	1		3.00E+05
controls	local backl	sector	broken	10	luminosity	mult	0	3.00E+05	1		0	1		3.00E+05
controls	Controls P	region	broken	2	luminosity	mult	0	3.00E+05	1		0	1		3.00E+05
controls	MPS & Fa	region	broken	1	luminosity	mult	0	5.00E+03	1		0	1		5.00E+03
AC power	Electrical>	Utility pow	broken	1	luminosity	mult	0	3.60E+05	4		0	2		3.60E+05
AC power	Electrical -	Utility pow	broken	10	luminosity	mult	0	3.60E+05	2		0	2		3.60E+05
	e- source	buncher												
Magnets	Bends	beamline	broken	0	luminosity	mult	0	2.00E+07	8		1	2		2.00E+07
Magnets	Quads	beamline	broken	10	luminosity	mult	0	2.00E+07	8		1	2		2.00E+07
Magnets	Corrs - car	beamline	broken	20	luminosity	mult	0	1.00E+07	2		1	2		1.00E+07
Magnets	Solenoids	beamline	broken	10	luminosity	mult	0	2.00E+07	8		1	2		2.00E+07
Magnets	Wigglers	beamline	broken	0	luminosity	mult	0	1.00E+07	8		1	2		1.00E+07

Starting Modeling Assumptions (XFEL/ILC)

- The full complement of 117 cryomodules is installed.
- (Only 3 upstream /all) klystrons+modulators are accessible.
- Accelerator can run with any other klystron off.
- (Few/Most) electronics modules can be hot swapped.
- Tune up dump and shielding between each part of accelerator
- Global controls causes (0.2/0.2)% downtime
- Global water system causes (0.2/0.0)% downtime
- Some cryoplant is down 1% including outages due to their incoming utilities. There is (1/6) cryoplant.
- Major power circuits cause (0.5/0.5)% downtime

Starting Modeling Assumptions (XFEL/ILC)

- Power coupler interlock electronics and sensors (do not have / have) MTBF of 1E6 due to redundancy.
- Cavity tuner motors have MTBF of 1E6, 2 times better than SLAC warm experience and MUCH better than TTF experience.
- Failed linac quads can be tuned around in 2 hours
- Most failed correctors can be tuned around in 0.5 hours
- LLRF, klystron support electronics, SC quad supplies (are/are not) in accel tunnel. Other power supplies are accessible
- Hot spare klystron/modulator with waveguide switches in (no/low energy) linac regions
- Magnet power supply MTBF of (50,000 for most magnets and 100,000 for SC magnets whose supplies are in the tunnel/200,000). ILC assumed redundant regulators.
- It takes (6/8) hours to replace a klystron

Initial downtime causes

Sum of % down * 100	
comp name	Total
cryo plant beamline	127.3
Kicker pulser beamline	104.9
coupler interlock electronics coupler	100.6
coupler interlock sensors coupler	99.8
Power supplies strings beamline	97.1
Power supplies SC quad beamline	65.5
site power beamline	65.2
Quads beamline	49.9
Flow Switch - quads beamline	44.0
Electrical - .05<<0.5 Utility power	35.1
Vac Mech device beamline	34.7
PS controller - corr can tune around beamline	34.5
PS controller SC quad beamline	27.8
Central Water beamline	25.2
Kickers beamline	24.8
local backbone sector	24.7
Controls sitewide beamline	23.1
PS controller string beamline	23.1
schedMaintn	17.9
Klystrons klystron	17.4

24 electronic cards + 6*24 sensors per RF unit – any failure trips it off

Lumped systems

Total XFEL downtime = 11.6% where budget = 7%

Total ILC downtime = 31% where budget = 15%, but ILC started with some components assumed better than now

Needed XFEL MTBF Improvements

Device	Needed Improvement factor	Downtime (%) due to these devices	Nominal MTBF (hours)	Nominal MTTR (hours)
coupler interlock electronics	**10**	0.1	100,000	1
coupler interlock sensors	**10**	0.1	600,000	1
power supplies - string	**5**	0.2	50,000	2
power supplies SC quads	**2**	0.3	100,000	1
add redundant kicker + Pulsar	**12->13**	0.2	7,000	2
flow switch	**3**	0.2	250,000	1
local controls backbone - sector		0.3	100,000	1
cryoplant		1.4		
site power		0.7		
controls - global		0.2		
central water plant		0.2		
schedule maintenance overrun		0.2		
klystrons		0.2	40,000	6
regional MPS system		0.2	5,000	1

Comments on MTBF improvements

- There are 6 coupler sensors and interlock electronics channels per coupler with no redundancy. Not surprising it is a problem. However, not problem at FLASH, so maybe MTBF of 100k hours per 6 channel electronics card is too short? Can one require 2 problems before tripping (ILC assumes this)?
- Kicker problem easily fixed with extra kicker and pulser. Was already OK for 17.5 GeV energy
- Power supplies are single points of failure, commonly a problem in accelerators.
  - APS gets MTBF of 560,000 hrs, 10 times greater than SLAC/FNAL/DESY.
  - They stress the supplies before each run and monitor internal temperatures and voltages so degrading components can be replaced on scheduled maintenance days.

Needed ILC MTBF Improvements

Device	Needed Improvement factor	Downtime (%) due to these devices	Nominal MTBF (hours)	Nominal MTTR (hours)
power supplies	**20**	0.2	50,000	2
power supply controllers	**10**	0.6	100,000	1
flow switches	**10**	0.5	250,000	1
water instrumention near pump	**10**	0.2	30,000	2
magnets - water cooled	**6**	0.4	3,000,000	8
kicker pulser	**5**	0.3	100,000	2
coupler interlock sensors	**5**	0.2	1,000,000	1
collimators and beam stoppers	**5**	0.3	100,000	8
all electronics modules	**3**	1.0	100,000	1
AC breakers < 500 kW		0.8	360,000	2
vacuum valve controllers		1.1	190,000	2
regional MPS system		1.1	5,000	1
power supply - corrector		0.9	400,000	1
vacuum valves		0.8	1,000,000	4
water pumps		0.4	120,000	4
modulator		0.4	50,000	4
klystron - linac		0.8	40,000	8
coupler interlock electronics		0.4	1,000,000	1
vacuum pumps		0.9	10,000,000	4
controls backbone		0.8	300,000	1

XFEL Simulation Results

Run Number	XFEL description	Simulated % unsched time down incl forced MD	Simulated % time fully up taking data or sched MD	Simulated % scheduled maintenance
XFEL1	TDR 20 GeV 8 + 4 sched down every 2 weeks	11.6	84.8	3.5
XFEL2	XFEL1 but 17.5 GeV	10.0	86.4	3.5
XFEL3	XFEL1 but MTBF table A	7.0	89.4	3.5
XFEL4	XFEL3 but no sched down	7.3	92.7	0.0
XFEL5	XFEL3 but sched down every 4 weeks	7.1	91.1	1.8
XFEL6	XFEL3 but 8 + 8 hour sched down	6.6	88.6	4.7

For ILC availSim used as input for many design decisions

- Putting both DR in a single tunnel only decreased int lum by 1%. -- OK
- Is a hot spare e+ target line needed? -- Not if e+ target can be replaced in the specified 8 hours
- Confirm that 3% energy overhead is adequate in the linac.
- Showed that hot spare klystrons and modulators are needed where a single failure would prevent running.
- Showed 7% availability loss for single tunnel.

For XFEL points out potential problems

- I’ve chosen particular items to improve.
- Project needs to look for optimum (cheapest, lowest risk) solution
- Could the cryoplant or site power be made more reliable than assumed?
- Can coupler interlocks require 2 problems before tripping?

Benchmarking the Simulation

- A limited benchmark was done with HERA data. Using MTBFs and component counts taken from HERA as input, it correctly calculated the number of failures.
- Fancier features like repair time scheduling and recovery time have not been benchmarked.
  - Getting together list of components is real work.
  - MTBFs and MTTRs should be taken from accelerator under study. 50% errors easily happen. Real work.
  - Recovery time is usually accounted as “tuning” instead of downtime.
  - Often repairs are accounted as “scheduled downtime”
- Simulation results seem reasonable. Back-of-the-envelope checks are OK.
- Most important results are comparisons of two slightly different accelerators. Systematic errors cancel.

Conclusions

- Component availability for ILC is a major challenge. Must do R&D, plan, and budget for it up-front.
- For XFEL, it is not past state-of-the-art, but more attention must be paid to it than for a typical HEP accelerator.
- X-ray beam-lines have not been modeled. They have few parts but with unknown reliabilities.
- This simulation is a useful design tool for the ILC and XFEL and other accelerators. Code is available.

Risk register

XFEL
X-Ray Free-Electron Laser

European XFEL Risk Register

Date: 10.01.2008

ID	Area of Project / Work Package	Risk Description	Risk Type	Possible Consequences	Impact	Probability	Severity of Risk	Date of Risk Identification	Date when Risk Consequences Start Affecting the Project	Risk Mitigation Mechanisms	Overall Responsible Person
G.01	Governments	delay in signing the convention	organizational	Delay of establishment of XFEL Company, Expiry of commitment period of tenderers	severe	medium	orange	10.12.2007	May 2008	Information of delegations	ISC
G.03	General	MSPE2007 unstable: cache problem causes error messages when pasting on empty cache	schedule	possible corrupted WP plans or project database, loss of users acceptance	severe	high	red	21.12.2007	now	keep up pressure on Microsoft to provide Hotfix, SP1 is not going to resolve this problem!	Microsoft, XPO, IT
G.04	General	Problem with hiring specialized manpower in many areas (competiveness in salary, economy)	organizational		severe	high	red				All
G.05	General	Shortage of man power in Desy groups due to parallel construction on Petra3	organizational		severe	high	red				All
G.06	General	Delivery time of components and material delayed due to economy	schedule		severe	high	red				Many
G.07	General	In-Kind process likely delays process due to knowhow transfer, coordination and contracting efforts	organizational		severe	medium	orange			Speed up process of in-kind negotiations	XFEL, DESY, partner institutions
G.08	General	In-kind Process possibly hampered by adjusting of different industry norms and safety requirements	technical		severe	medium	orange			Speed up process of in-kind negotiations	XFEL, DESY, partner institutions
G.09	General	Standards for crates needs to be defined (VME vs. ATCA vs.?)	technical		moderate	high	yellow			Workshop has been scheduled for December 4th, 2007 to decide on this issue	K. Rehlich, Many
01.01	WP-01: RF System	Need to find 2nd supplier of pulse transformers	sole supplier dependency	delay of project, increase of budget	severe	medium	orange	July 2007	autumn 2008	1. negotiate with Russian in-kind contributor 2. figuring out whether chinese companies can manufacture PT 3. contacted german company working in similar field	S. Choroba
02.01	WP-02: LLRF	Lack of commercial suppliers for Master Oscillator	no supplier		moderate	medium	pale			Additional suppliers being solicited.	S. Simrock
03.01	WP-03 Accelerator Modules	industrial price of cold mass and vacuum vessel not jet known, metal price inflation	budget		moderate	high	yellow	12.11.2007	spring 2009	Qualify 2 manufacturers to build cold mass and vacuum vessel for the modules	R. Lange

High Impact, High Probability	red	Moderate Impact, High Probability	yellow
High Impact, Medium Probability	orange	Moderate Impact, Medium Probability	pale

XFEL
X-Ray Free-Electron Laser

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Date: 10.01.2008

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03.03	WP-03 Accelerator Modules	Transfer of all knowledge and special details of module experience to CEA and from CEA to industry	schedule		moderate	medium	pale	12.11.2007	autumn 2008	CEC-Saclay has to be introduced by DESY and INFN in all things concerning XFEL accelerator modules as fast as possible	R. Lange
04.01	WP-04: SC Cavities	Such a large series of cavities never been mechanically fabricated and treated	technical	Delivering delay	moderate	high	yellow	26.09.2007	autumn 2008	Qualifying several companies, preseries fabrication	W. Singer
04.02	WP-04: SC Cavities	Infrastructure problems at companies can lead to large time shifts	technical	Delivering delay	moderate	high	yellow	26.09.2007	autumn 2009	Upgrade and set up of new infrastructure, advising	W. Singer
08.01	WP-08: Cold Vacuum	latest schedule shows a too short installation time	schedule	delay of start of commissioning	severe	medium	orange	26.09.2007	late stage	work out proper schedule with all involved parties	XFEL PM
12.01	WP-12: Warm Magnets	Changing of the magnet parameters after starting tender procedure	schedule	delay in delivery of magnet type; more money will be involed	moderate	medium	pale	26.09.2007	spring/summer 2008		B. Krause
14.01	WP-14: Injector	Manpower inadequate, laser expert needed	organizational		severe	high	red			recruiting in progress, continuation of contract with Max Born Institute (Berlin) in preparation	K. Flöttmann
17.02	WP-17: Standard Beam Diagnostic	time contracts of sole knowledge carries in the BPM area (T. Traber: Knopfmonitorelektronik, D. Lipka: RF Design Cavity/Knopfmonitor)	sole supplier dependency	time delay of years, if people find more attractive offers outside Desy	severe	medium	orange	29.11.2007			Desy
18.01	WP-18: Special Beam Diagnostic	Transverse deflecting structure not covered by manpower	technical		moderate	high	yellow			negotiate with Russian in-kind contributor	H. Schlarb
71.01	WP-71: Undulator	Build up of staff for XFEL dedicated work; Part of problem is workload of DESY team preparing PETRA-III	schedule	Delay of undulator production, installation	severe	medium	orange	Fall 2007	Jan 08	Make staffing plan and build up a dedicated XFEL undulator group	J. Pflueger, XFEL management
71.02	WP-71: Undulator	Availibility of laboratory space for R&D and magnetic measurements	schedule	Delay of R&D activities	severe	medium	orange	Fall 2007	Jan 08	Conclude cooperation with DESY on use of existing laboratories	XFEL management

High Impact, High Probability	(red)	Moderate Impact, High Probability	(yellow)
High Impact, Medium Probability	(orange)	Moderate Impact, Medium Probability	(pale)

European XFEL Risk Register

Date: 10.01.2008

ID	Area of Project / Work Package	Risk Description	Risk Type	Possible Consequences	Impact	Probability	Severity of Risk	Date of Risk Identification	Date when Risk Consequences Start Affecting the Project	Risk Mitigation Mechanisms	Overall Responsible Person
71.03	WP-71: Undulator	Cost for undulator systems might exceed budget book significantly.	budget	Increased cost	moderate	high	yellow	Fall 2007		Develop strategies for more cost effective undulator construction	J. Pflueger
71.04	WP-71: Undulator	Strategy and instrumentation to provide variable polarization at SASE 3 not defined	technical	Affects the transition from the start-up scenario to TDR	small	low	pale	Fall 2007	2015	Start dedicated R&D on this issue. This involves WPs 21, 22/23, 24, 27 and e-beam dynamics and diagnostics	J. Pflueger
72.01	WP-72: FEL Concepts	Simulations to get circular polarized light from SASE3 not finalized	technical	Affects the transition from the start-up scenario to TDR	small	low	pale	Fall 2007	2015	Start dedicated R&D on this issue. This involves WPs 21, 22/23, 24, 27 and e-beam dynamics and diagnostics	M. Yurkov
73.01	WP-73: X-ray optics & beam transport	Availibility of laboratory space for R&D	schedule	Delay of R&D activities	moderate	medium	pale	Fall 2007	Aug 08	Conclude cooperation with DESY or other collaborating institutes about use of laboratories	XFEL management
74.01	WP-74: Photon Diagnostic	Defintion WP leader	schedule	Delay of R&D activities	moderate	high	yellow	Fall 2007	Jan 08	XFEL management searches qualified candidates	XFEL management
74.02	WP-74: Photon Diagnostic	Refinement and verification of baseline concept for beam based alignment of undulators and its integration into an overall commissioning strategy not finished	schedule	A delay could lead to change of instrumentatation causing a delay in the planning. In the worst case this might affect the commissioning or even performance of the FELs.	severe	medium	red	Fall 2007	Jan 09	Form dedicated working group	K. Tiedtke
75.01	WP-75: Detector Development	Radiation dose to high for detectors	technical	Affects technical realisation, cost and schedule for development of 2D pixel detectors	moderate	medium	yellow	Spring 2007		Start dedicated R&D including experimental verification on this issue.	H. Graafsma
75.02	WP-75: Detector Development	Charge deposition too high for detectors	technical	Affects technical realisation, cost and schedule for development of 2D pixel detectors	moderate	medium	yellow	Spring 2007		Start dedicated R&D including experimental verification on this issue.	H. Graafsma
31.01	WP-31: Site & Civil Construction	Current state of economy could lead to large overrun in cost	budget		severe	medium	orange			No action possible, Call for tenders finished December 2007; cost risk known by that time	All
31.02	WP-31: Site & Civil Construction	Ownerships of construction sites are still unsettled	organizational	start of the construction project may begin later on	moderate	medium	pale	26.09.2007		Ownerships are going to be cleared up judicial	XFEL

High Impact, High Probability	red	Moderate Impact, High Probability	yellow
High Impact, Medium Probability	orange	Moderate Impact, Medium Probability	pale

European XFEL Risk Register

Date: 10.01.2008

ID	Area of Project / Work Package	Risk Description	Risk Type	Possible Consequences	Impact	Probability	Severity of Risk	Date of Risk Identification	Date when Risk Consequences Start Affecting the Project	Risk Mitigation Mechanisms	Overall Responsible Person
31.03	WP-31: Site & Civil Construction	legal contest for call for tender can be expected for such large contracts	schedule	start later?	moderate	high	yellow			No action possible, situation clarifies March 2008	All
33.02	WP-33: Tunnel Installation	Safety rules/margins for suspension designs due to hanging loads	budget	Design changes needed; higher effort in fabrication and for quality control (X-raying, etc.)	moderate	high	yellow	Sep 07	2010	Risk analysis; settle safety margins and quality control	N.Meyners, XFEL PM
33.06	WP-33: Tunnel Installation	Safety requirements if half of the floor plates (XTL) are remove during pulse cable installation	budget	A variable railing system may be needed	moderate	high	yellow	spring 07	2012	Risk analysis; settle safety concept	N.Meyners, XFEL PM
34.01	WP-34: Utilities	Review of the utilities and infrastructure by the GMSH (Gebäudemanagement Schleswig-Holstein)	manpower	delay of occupancy of tunnels and buildings	severe	high	red	July 2007	2008	engage engineering office	J.-P- Jensen
34.02	WP-34: Utilities	Manpower bottleneck in the area of design, purchasing, construction supervision of the electrical installation	manpower	delay of occupancy of tunnels and buildings	moderate	high	yellow	July 2007	2009	engage temporary engineers, technicians and drawers	J.-P- Jensen
34.03	WP-34: Utilities	Cost increase for cables, switchgears and electrical installation	budget	overdraw of the budget	moderate	high	yellow	July 2007	2009	investigate possible cost savings, as aluminum cables if possible	J.-P- Jensen
34.06	WP-34: Utilities	Manpower bottleneck in the area of design, purchasing, construction supervision of the water cooling installation	manpower	delay of commissioning of the water cooling	moderate	high	yellow	June 2007	2010	engage temporary engineers, technicians and drawers	J.-P- Jensen
34.07	WP-34: Utilities	Cost increase for pipes, pumps, recooler, fittings, mountings, chillers etc	budget	overdraw of the budget	moderate	high	yellow	July 2007	2009	investigate possible cost savings, as waiving of redundancy or spare, reduced number of recooler	J.-P- Jensen
34.08	WP-34: Utilities	severe manpower bottleneck in area of heating, ventilation and air conditioning	organizational		moderate	high	yellow			Investigate need to put part of the work to industry	J.-P- Jensen
34.09	WP-34: Utilities	air conditioning, ventilation&heating system cost estimate possibly too low	budget		moderate	high	yellow	July 2007	2008	investigate possible cost savings	J.-P. Jensen

High Impact, High Probability	(red)	Moderate Impact, High Probability	(yellow)
High Impact, Medium Probability	(orange)	Moderate Impact, Medium Probability	(light yellow)

European XFEL Risk Register

Date: 10.01.2008

ID	Area of Project / Work Package	Risk Description	Risk Type	Possible Consequences	Impact	Probability	Severity of Risk	Date of Risk Identification	Date when Risk Consequences Start Affecting the Project	Risk Mitigation Mechanisms	Overall Responsible Person
34.10	WP-34: Utilities	cost increase for automation and controller systems of water cooling	budget	overdraw of the budget of water cooling	moderate	high	yellow	July 2007			
34.11	WP-34: Utilities	Manpower bottleneck in the area of design, purchasing, construction supervision of the automation and controller systems	manpower	delay of commissioning of the water cooling	moderate	high	yellow	July 2007	2010	engaging temporary engineers, technicians and drawers	J.-P- Jensen
35.01	WP-35: Radiation Safety	legal aspects regarding resposibility	organizational		severe	medium	orange	July 2007		Transfer of property, operational responsibility to be clarified in relation Desy-GmbH (organization in charge of operation must also be in charge of radiation protection)	tbd, needs to participate in GmbH contract negotiations
36.01	WP-36: General Safety	What part of this should be taken over by the GmbH?	organizational		moderate	medium	pale			Study legal implications and practical implementation; try to absorb into XFEL-DESY contracts	S. Schrader, XFEL, AFI

High Impact, High Probability	(red)	Moderate Impact, High Probability	(yellow)
High Impact, Medium Probability	(orange)	Moderate Impact, Medium Probability	(pale)