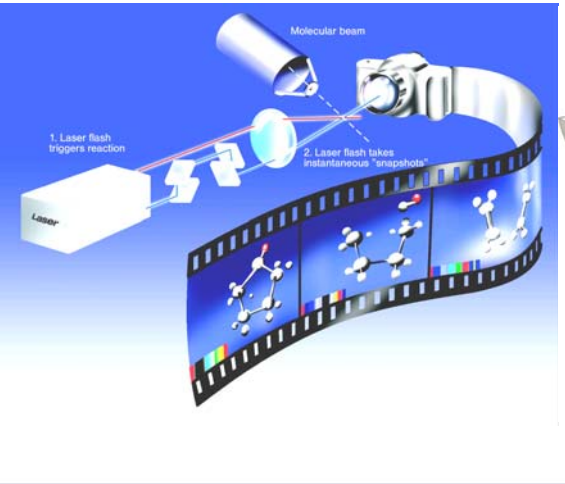
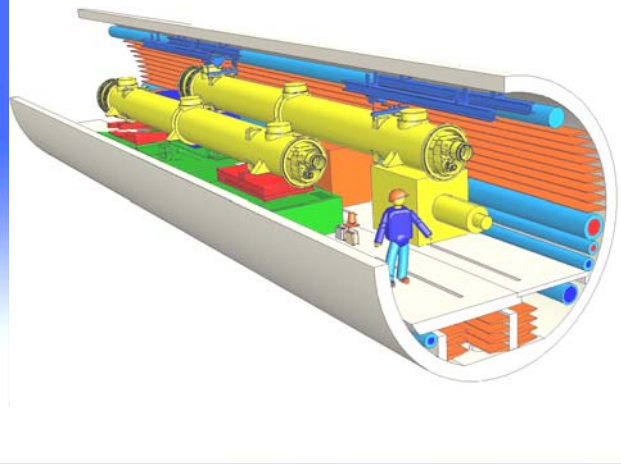
European XFEL Project Status and Industrialisation Programme

R. Brinkmann, DESY

for the XFEL team





Introduction

Proposal Oct. 2002 – X-ray FEL user facility with 20 GeV superconducting linear accelerator in TESLA technology

Approval by German government Feb. 2003 as European Project

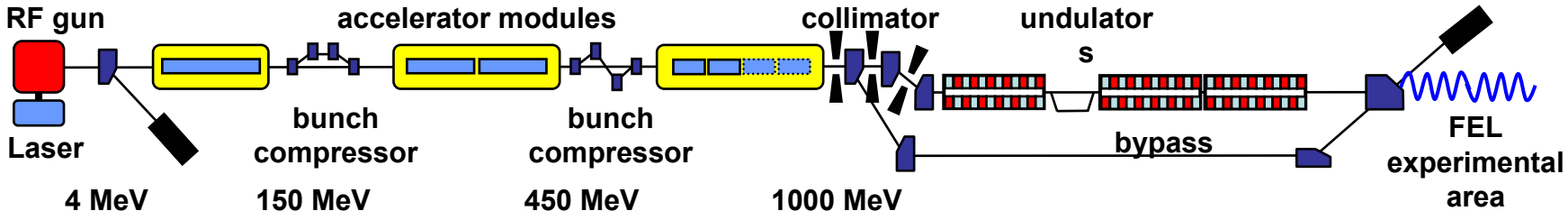
Commitment for 50% of funding + 10% by Hamburg & Schleswig-Holstein, 40% European & international partners

Introduction cont'd

- Project preparation phase: get ready to start construction by beginning of 2007
  - Finalize overall layout and technical design
  - Detailed planning for the new site near DESY
  - Industrialization of major technical components
  - Update of project construction and operation cost estimate
  - Project organization at the European/International level

Introduction cont'd

TESLA Test Facility and the VUV-FEL:



→ Pilot facility regarding practically all aspects (accelerator technology, beam physics, FEL process, user operation) of the XFEL

→Test bed for technical developments specifically required for the XFEL

→ Injector development at PITZ, DESY-Zeuthen

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

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

WG on Scientific and Technical issues STI (chair: F. Sette, ESRF)

WG on Administrative and Funding issues AFI (chair: H.F. Wagner, Germany)

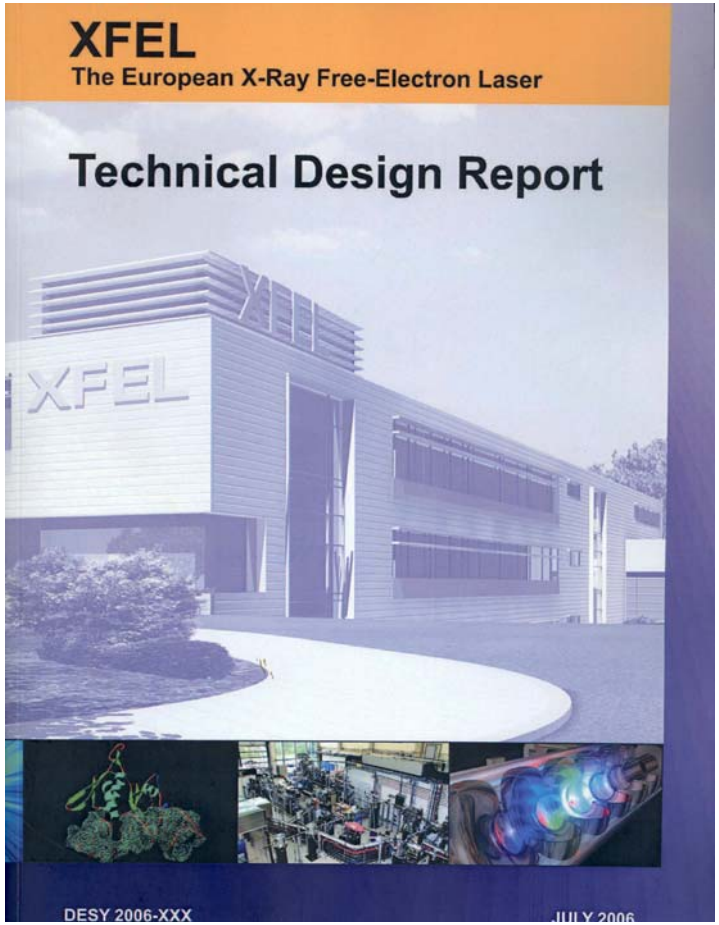
Bi-lateral negotiations between Germany and signature countries on funding contributions are ongoing

Completion of documents

Technical Design Report

- March 2006: Review of Accelerator & Infrastructure parts by STI + international experts
- May 2006: Review of Photon Beam Line & Experiments parts by STI + international experts
- July 2006: Complete TDR → ISC
  approved July 25 at ISC meeting

- Administrative documents essentially completed and delivered to ISC



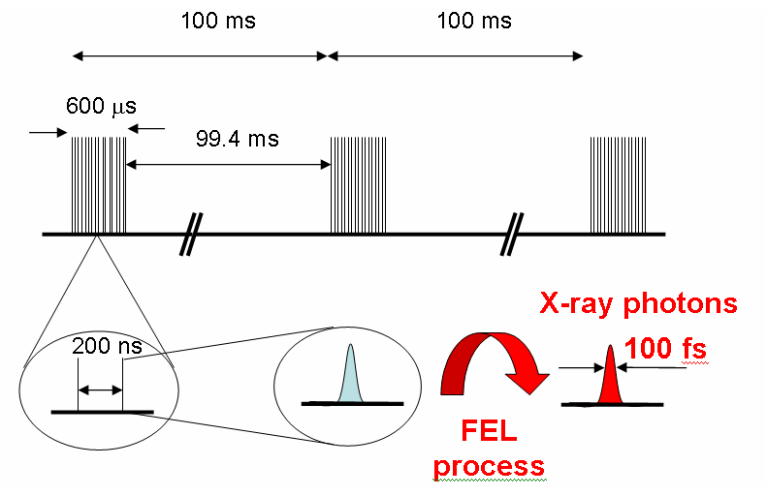
Properties of XFEL radiation

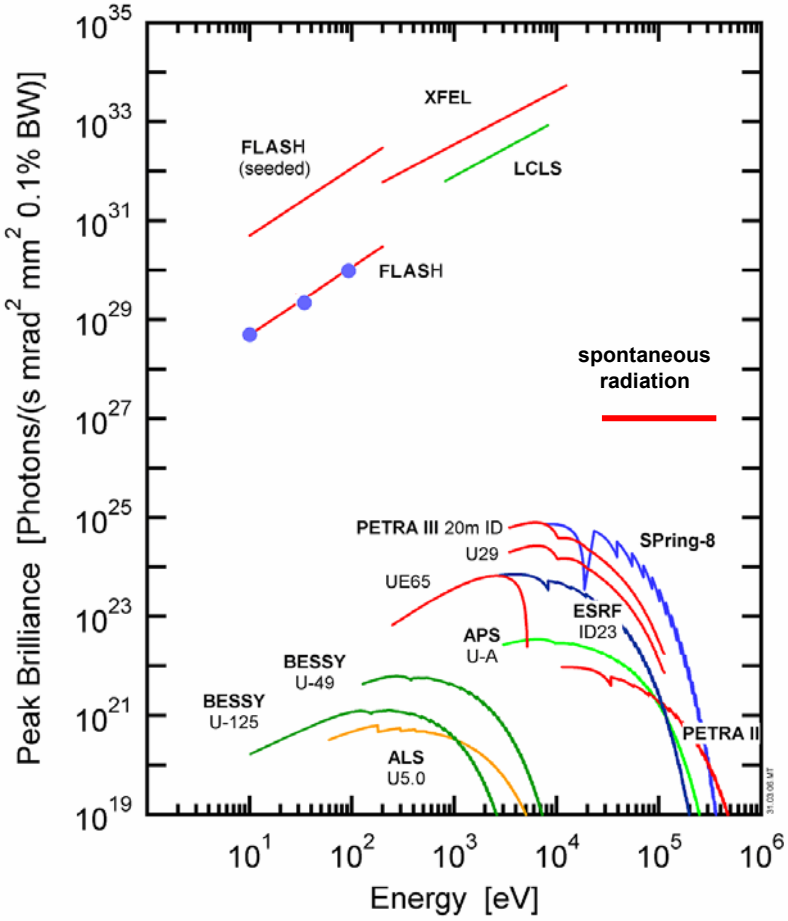
X-ray FEL radiation (0.2 - 14.4 keV)

- 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	H. Schunck (ISC)	
	Committee (ISC) for the European XFEL	R. Feidenhans'l (Scientific and Techn. Issues)	
	and its advisory groups	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)**		

Status of funding & project approval

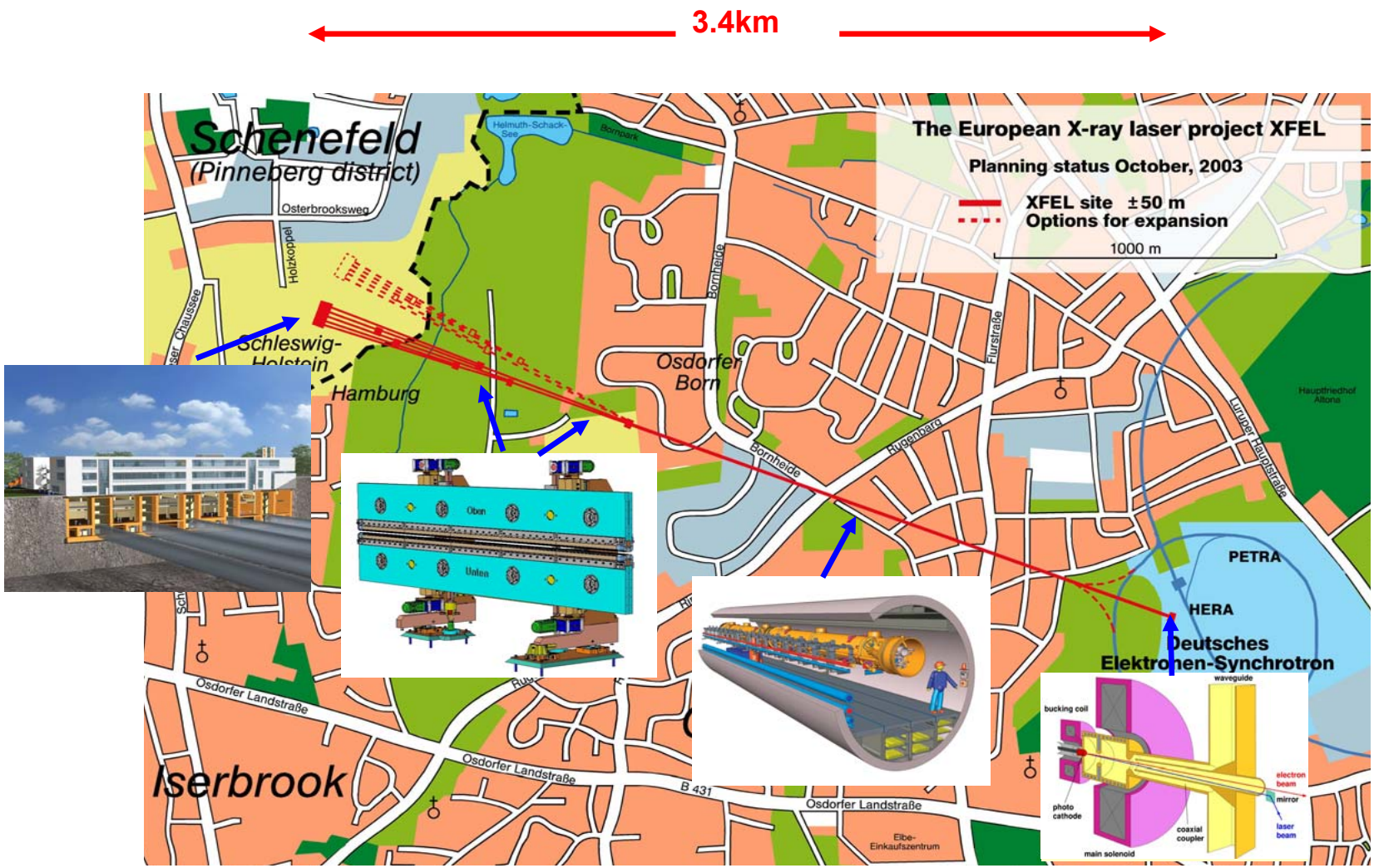
- Required budget for construction phase is 986 M€ (year 2005 price basis, not including project preparation & beam commissioning)
- As of today, commitment from partners > 200 M€

→ worked out an initially de-scoped start scenario (fully recoverable when funding becomes available) for the facility with 850 M€ construction cost, funded by Germany & partners 75%:25%

  - Initially only 3 of 5 undulator beam lines and 6 of 10 experimental stations installed
  - Accelerator reduced from 20 to 17.5 GeV energy (TDR baseline reference parameters not compromised, but operational overhead removed)

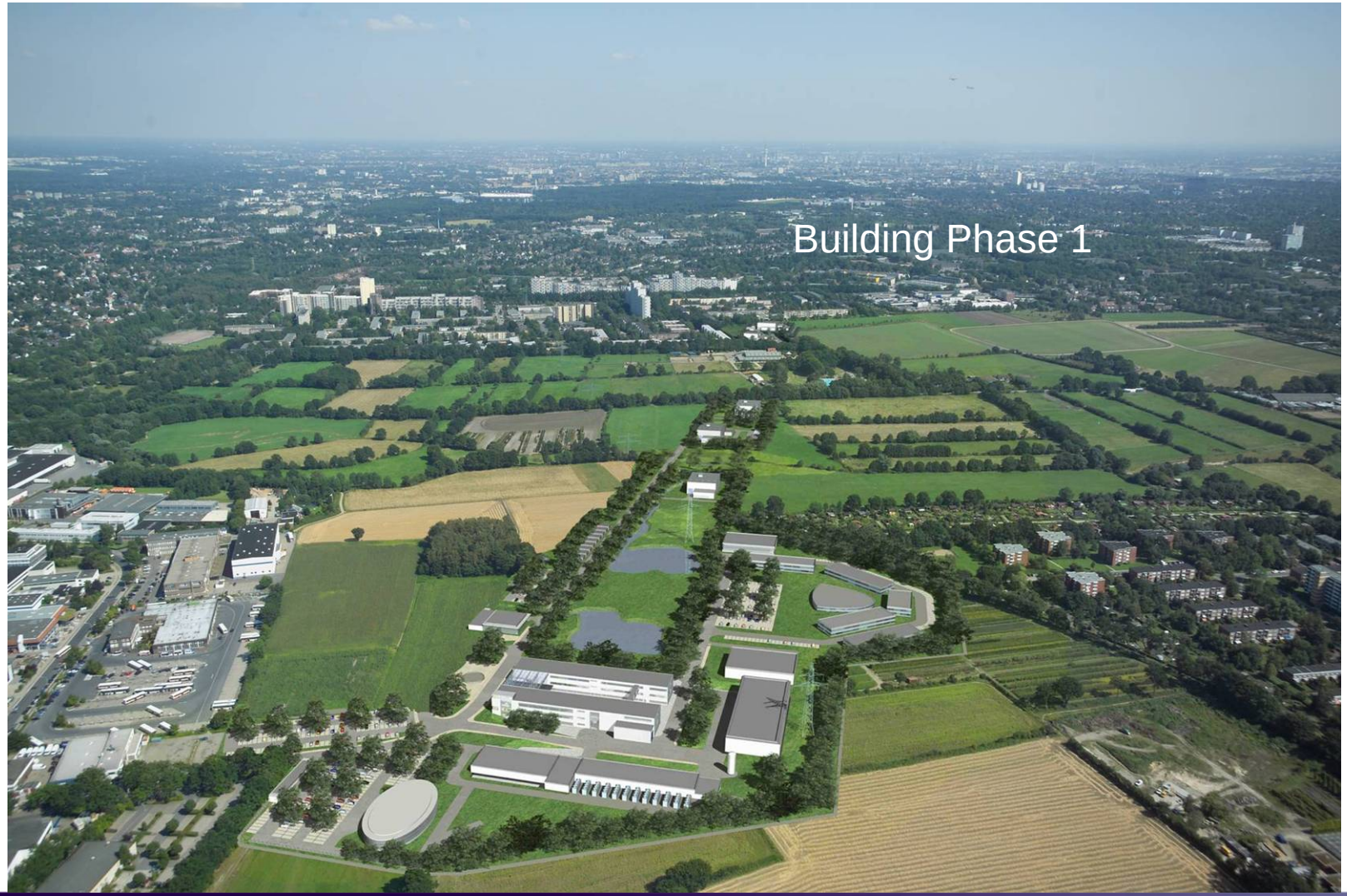
- Start scenario evaluated by STI and recommended to ISC
- May 3, 2007: ISC approves the start scenario
- Expect official go-ahead on June 5, 2007 and 1st steps of project realisation in 2nd half 2007
- First beam in 2013, all beamlines operational in 2015

Overall layout of the European XFEL



XFEL site in Hamburg/Schenefeld

… after construction *(computer simulation)*



Plan approval procedure – construction permission

May/June 2005: documents for PFV open to public; time to submit objections/complaints

Oct. 25/26 2005: Hearing

July 2006: Plan approval announced by authority in charge
(LBEG Clausthal-Zellerfeld)

Bekanntmachung

zum
Planfeststellungsbeschluss
für den Bau und Betrieb des Röntgenlasers XFEL einschließlich der für seinen Betrieb notwendigen Anlagen und Gebäude
des Deutschen Elektronen-Synchrotron (DESY), Hamburg

Der von der Stiftung Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, 22607 Hamburg, mit Datum vom 27.04.2005 vorgelegte Antrag zur Durchführung des Planfeststellungsverfahren für die Errichtung und den Betrieb des Freien-Elektronen-Lasers (Röntgenlaser oder XFEL) wurde festgestellt. Das Vorhaben ist damit genehmigt.

Der festgestellte Plan umfasst die im Antrag und seinen Planunterlagen dargestellte Errichtung und den Betrieb der Forschungsanlage. Sie setzt sich zusammen aus einem nordwestlich in rund 6 bis 38 Meter Tiefe verlaufenden ca. 3,4 km langen Tunnelbauwerk vom DESY-Betriebsgelände in Hamburg Bahrenfeld zum vorgesehenen XFEL Forschungsgelände, im Süden der Stadt Schenefeld im Kreis Pinneberg, Schleswig-Holstein sowie den zugehörigen Haupt- und Nebengebäuden.

Die Errichtung und der Betrieb der Forschungsanlage sind entsprechend dem festgestellten Plan sowie den in diesem Beschluss festgelegten Nebenbestimmungen auszuführen.

Eine Ausfertigung des Planfeststellungsbeschlusses und eine Ausfertigung des festgestellten Planes liegen zur Einsichtnahme für die Dauer von zwei Wochen zu jedermanns Einsicht bei folgenden Behörden öffentlich aus:

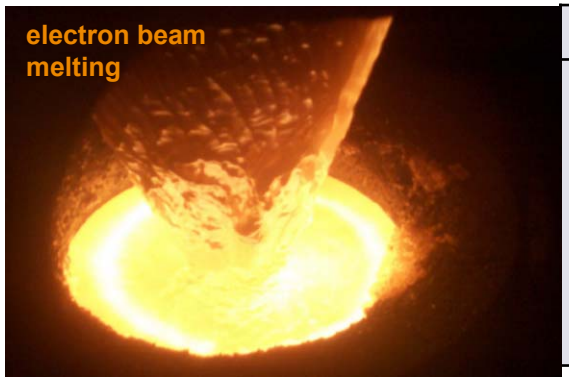
1. beim Bezirksamt Altona

   im Bauamt
   Stadtplanungsabteilung, Zimmer 342
   Platz der Republik 1,
   22767 Hamburg,

Montag bis Donnerstag	09.00 Uhr bis 16.00 Uhr
Freitag	09.00 Uhr bis 15.30 Uhr

(andere Zeiten sind erforderlichenfalls unter Tel. Nr.: 040/428111402 abzusprechen)

Cavity programme - Niobium



Electrical and mechanical properties of Nb	
Residual Resistivity Ratio RRR	> 300
Grain size	≈ 50 µm
Yield strength	> 50 N/mm^2
Tensile strength	> 140 N/mm^2
Elongation at fracture	> 30%
Vickers hardness HV 10	≤ 60

Content of the main impurities µg / g			
Ta	≤ 500	H	≤ 2
W	≤ 50	O	≤ 10
Mo	≤ 50	N	≤ 10
Ti	≤ 50	C	≤ 10
Fe	≤ 50		
Ni	≤ 50		

eddy current scanning of niobium sheets

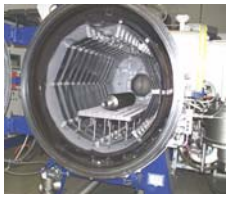
3 manufacturers + (recently) Chinese company qualified to deliver high-quality Niobium

2 manufacturers qualified for mechanical fabrication of 9-cell cavities

Baseline treatment procedure & performance

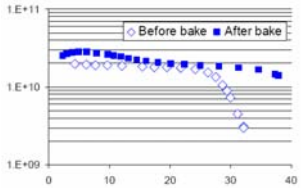
- Baseline treatment procedure with 1-step electropolishing (final step only short BCP)

EP 150 µm (inside)



UHV 800°C annealing

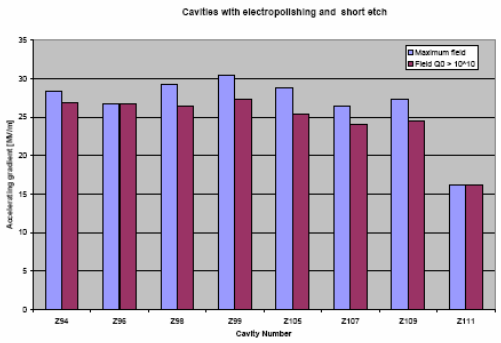
BCP 10 µm (inside)

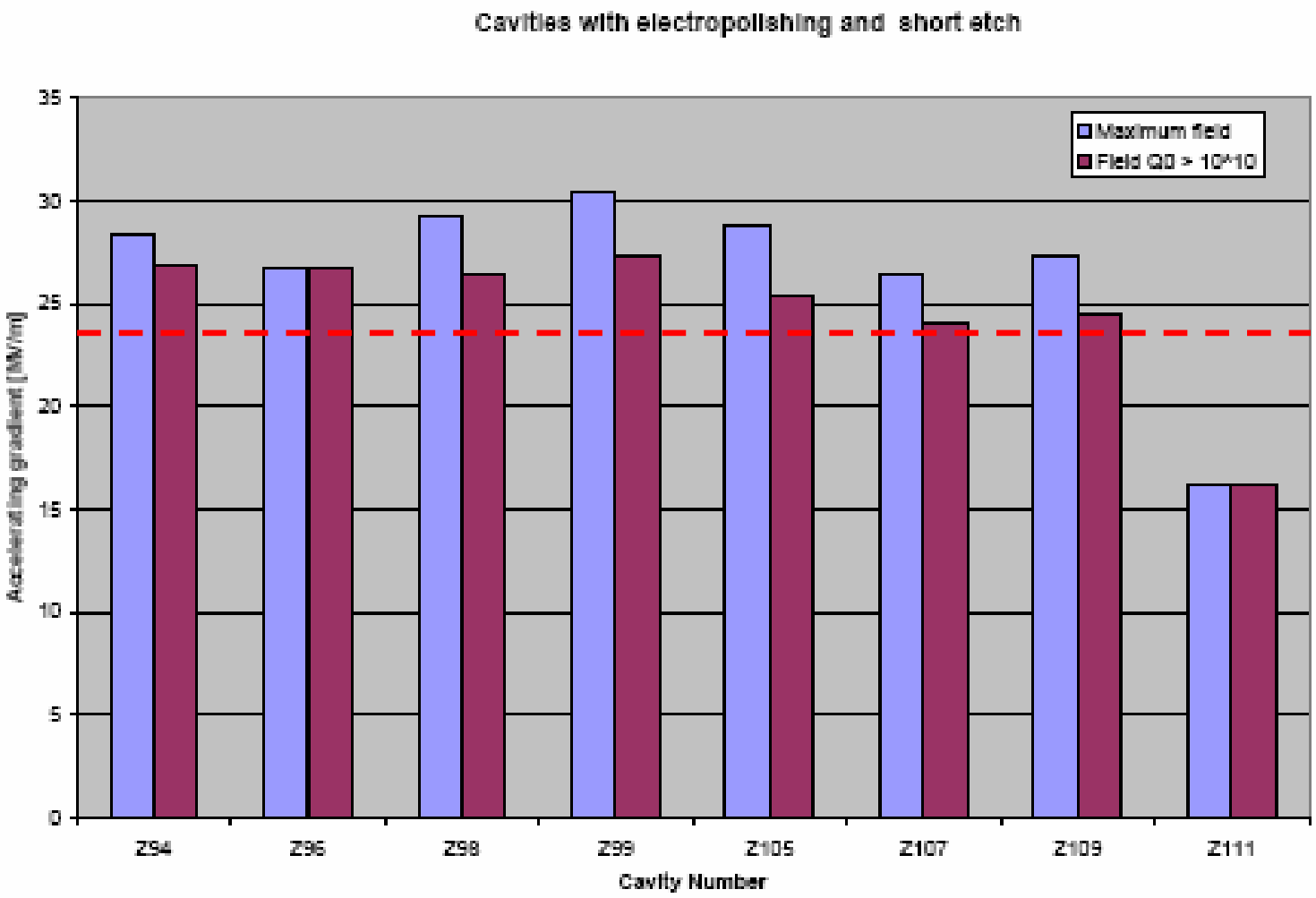


UHV 120°C baking

100 bar HPR (6 ×)

- Industrialisation of EP ongoing: have placed orders to two companies for treatment of 15 cavities each




Cavities with electropolishing and short etch
Maximum field
Field Q0 > 10^10
Accelerating gradient [MV/m]
35
30
25
20
15
10
5
0
Z94
Z96
Z98
Z99
Z105
Z107
Z109
Z111
Cavity Number

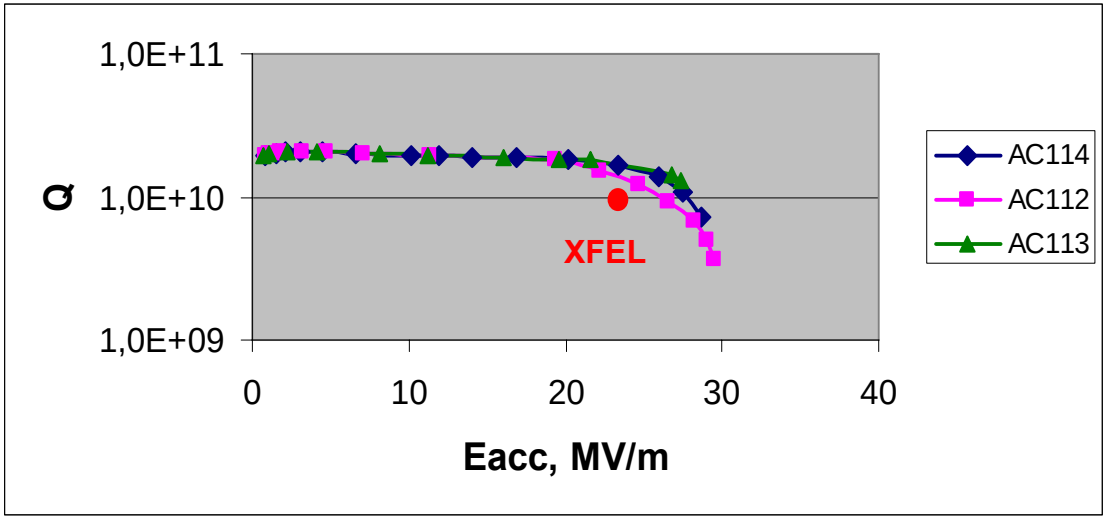
Alternative fabrication – large grain Nb

Fabrication from large-grain Niobium – cut sheets directly from ingot (method pioneered at 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

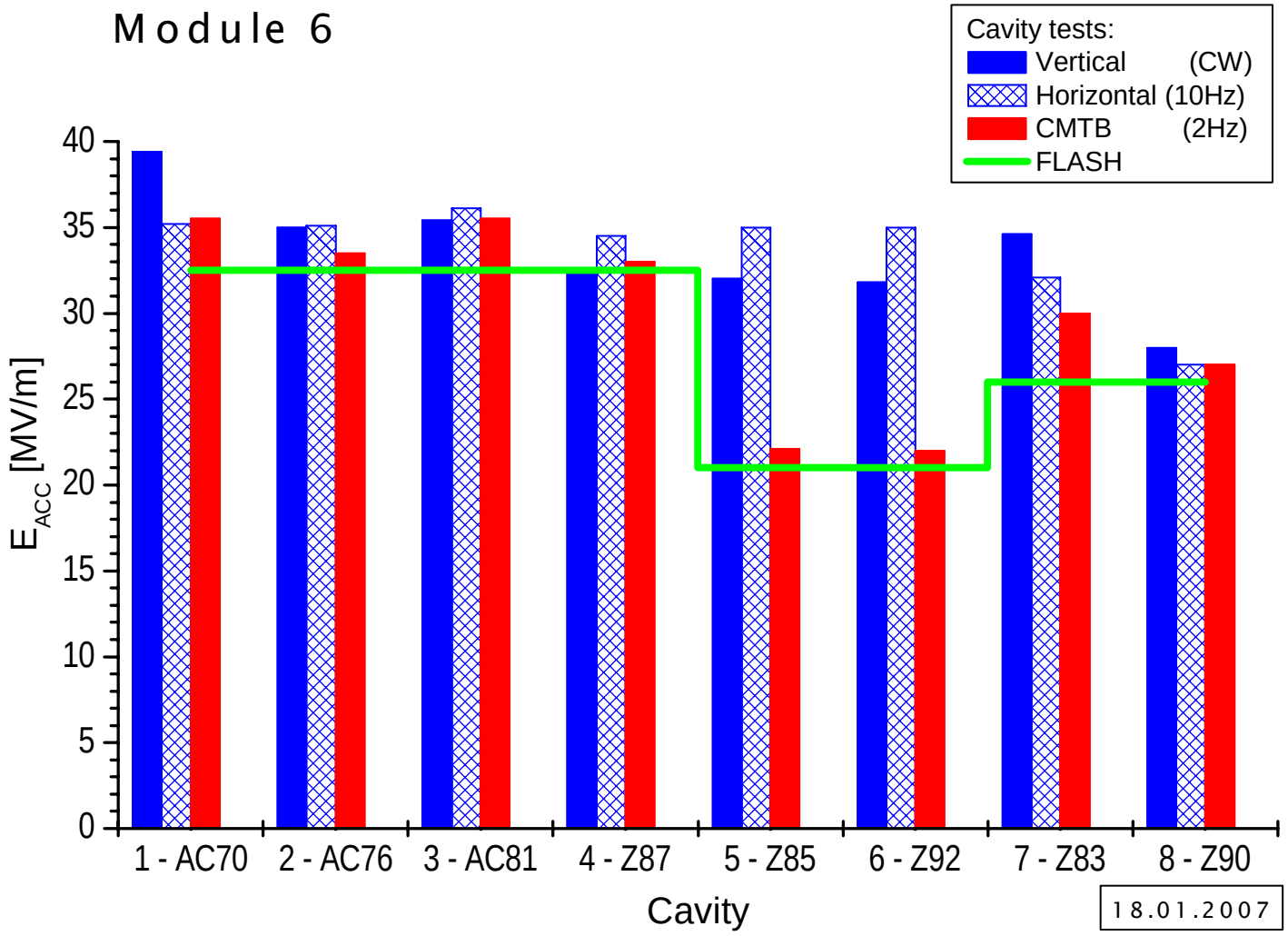
→Could later choose the more economic method for industrial production



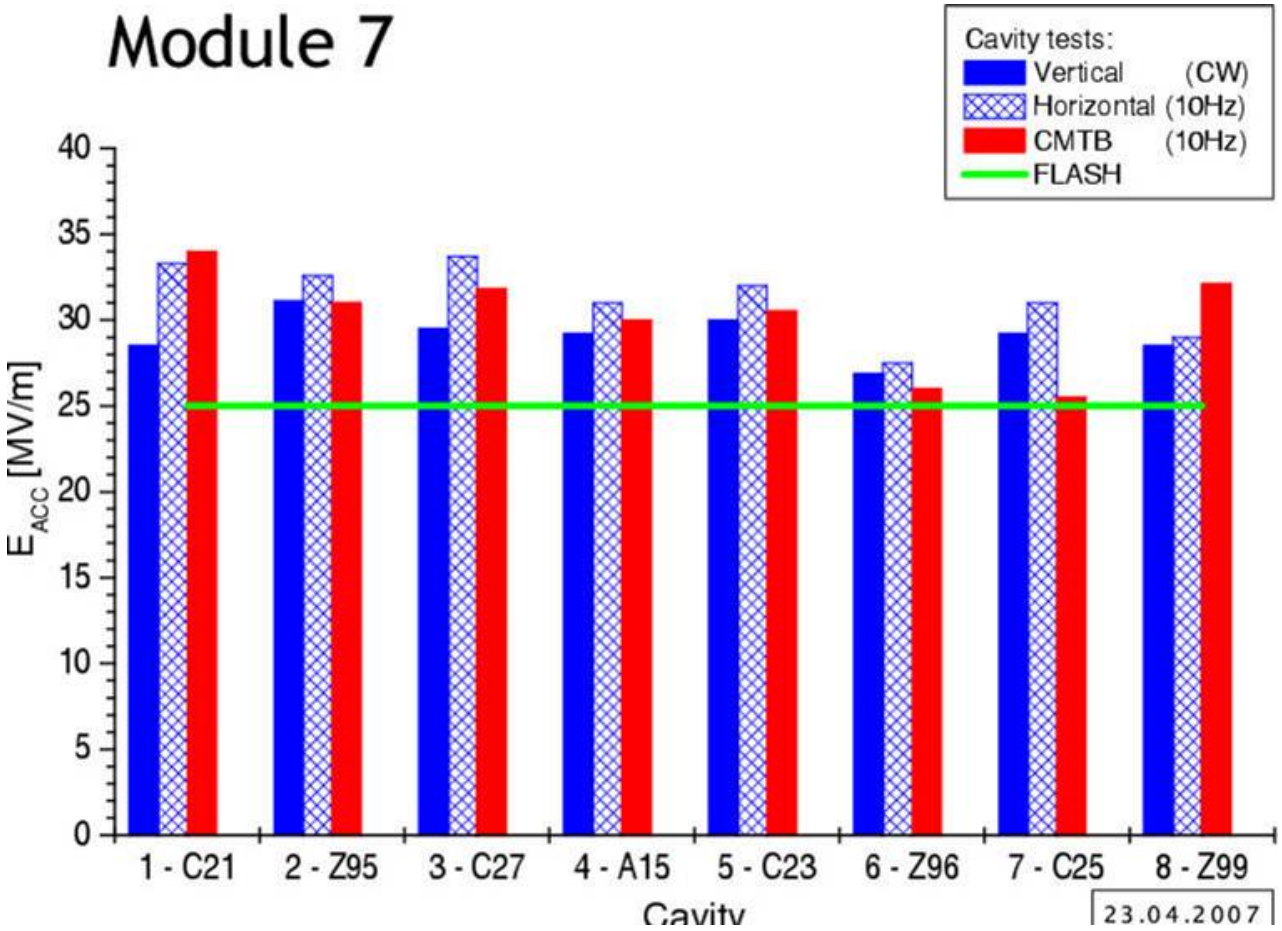
Cryomodule test bench

- CMTB permits test of modules (prototypes & pre-series) without the need to install them in the FLASH linac
- Construction & commissioning completed autumn 2006
- Modul #6 & 7 (→ FLASH) tests completed (coupler processing, cav performance, cryo load, cold-warm cycles, piezo-compensation, LLRF, …)
- Gain important experience for the later larger scale series test facility

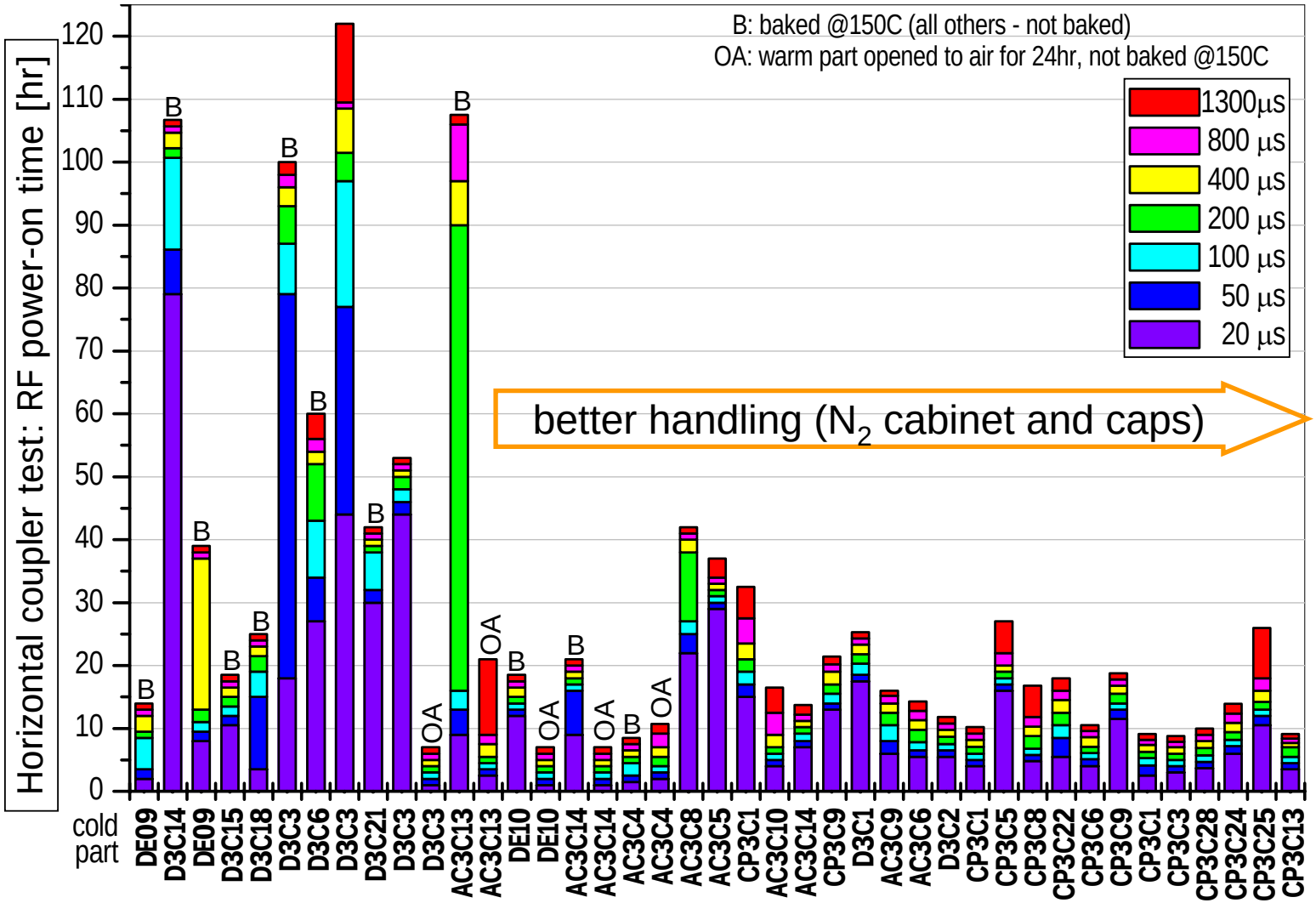
Module #6 test results at CMTB



Module #7 test results at CMTB



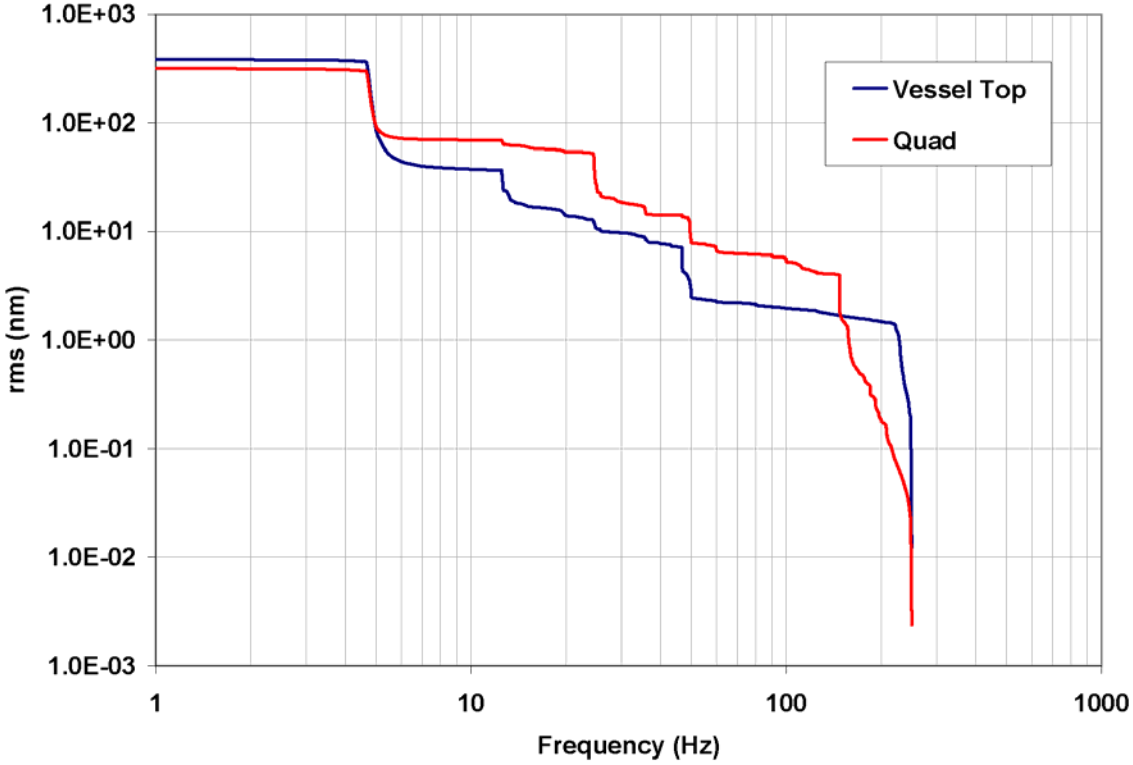
Fast coupler processing (in CHECHIA → in M6,7)



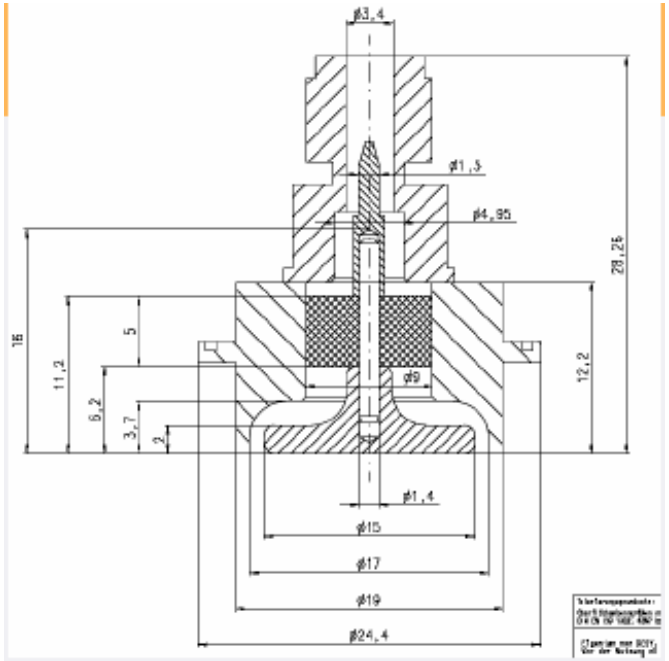
Vibration studies – stability within module

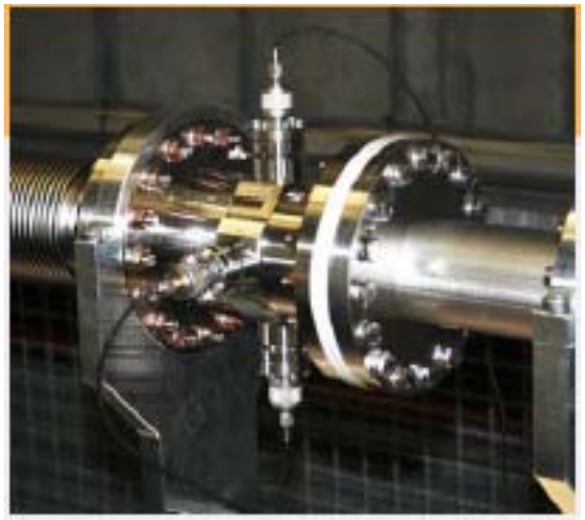
Work done within ILC/EUROTEV programme

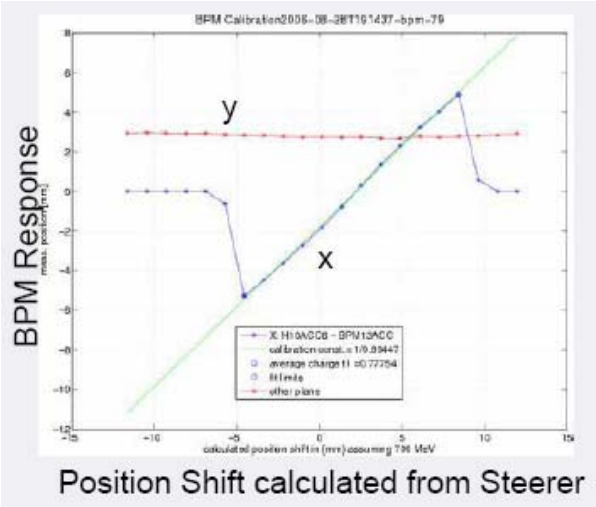
→ Overall amplification of quad vibration vs. external vibration of module vessel is small



Simple cold BPM: button type with HERA-like concept







Resolution 25 – 30 μm obtained with beam test in FLASH

Accelerator technology - collaborative effort

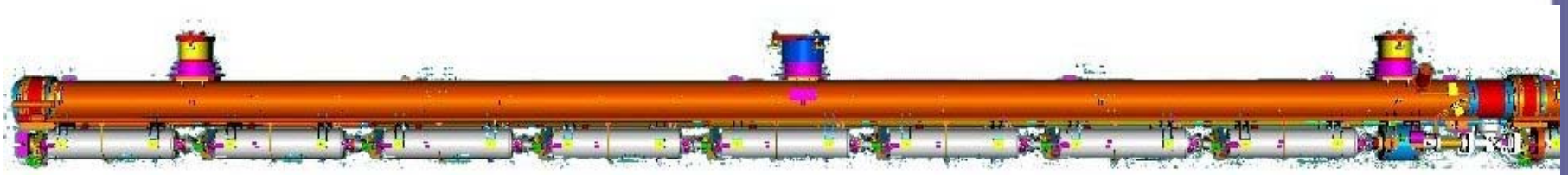
Industrial study module assembly (M6 done, M8 autumn 2007)

2 more cryostats (TTF3/INFN) delivered

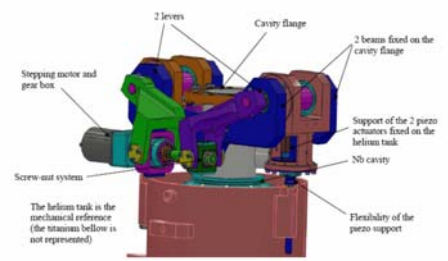
Superferric magnet (CIEMAT)

BPM (Saclay)

Integrated HOM absorber

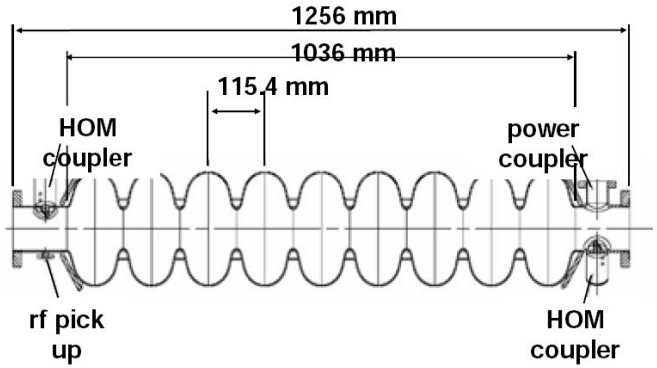


Length quantized n·λ/2 (possibility of ERL)

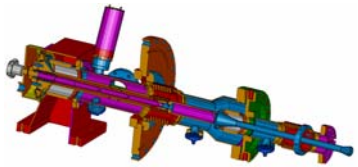


Tuner w/piezo (Saclay)

Industrialization in preparation



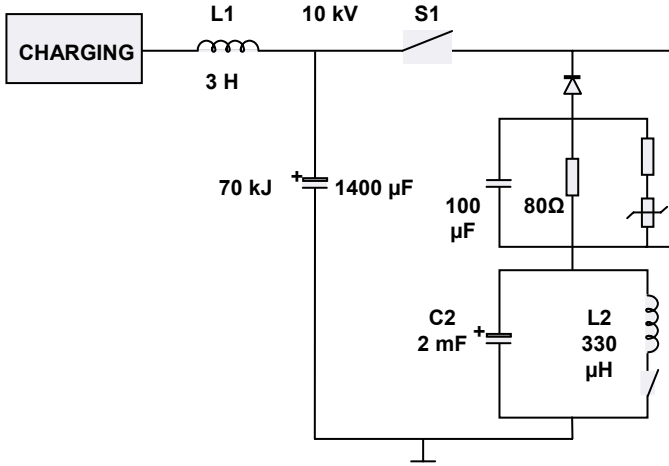
LLRF development (collab. Warsaw/Lodz)



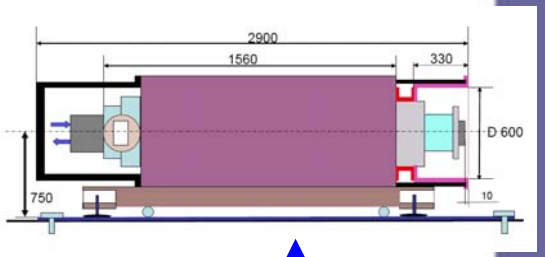
TTF3-type coupler

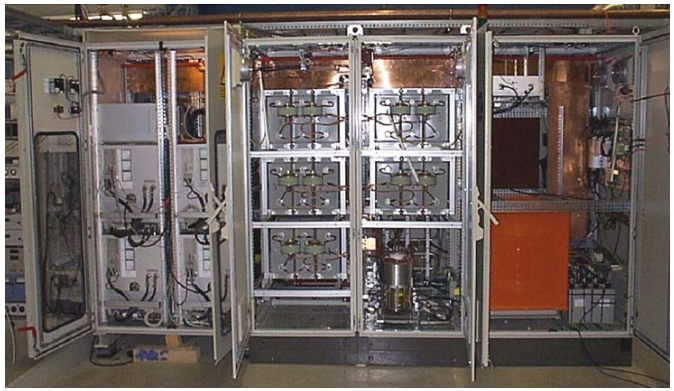
Industrialization launched (Orsay)

High Power RF System
(Modulator, Pulse Cable, Pulse Transformer, Klystron)



1:12 Pulse Transformer





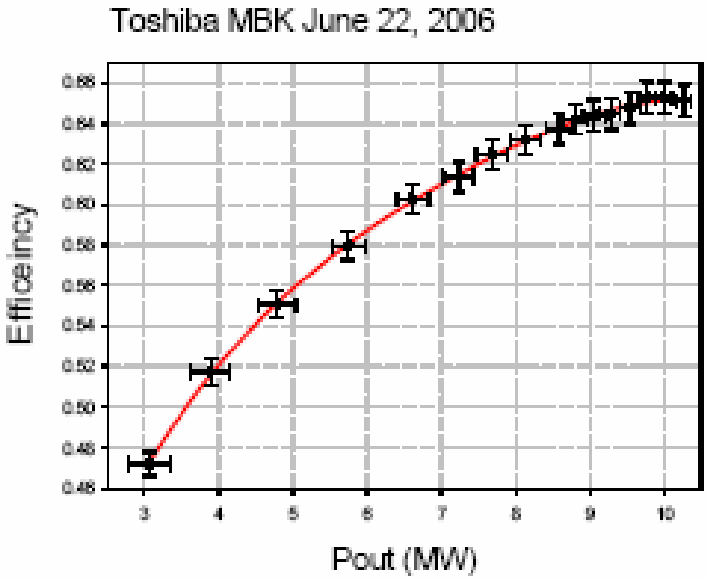
RF system - klystrons

Toshiba multi-beam klystron reached (more than) full performance spec

CPI klystron reached > 8 MW

Recently, last Thales klystron also looks very good

→ Have qualified three klystron manufacturers for XFEL spec

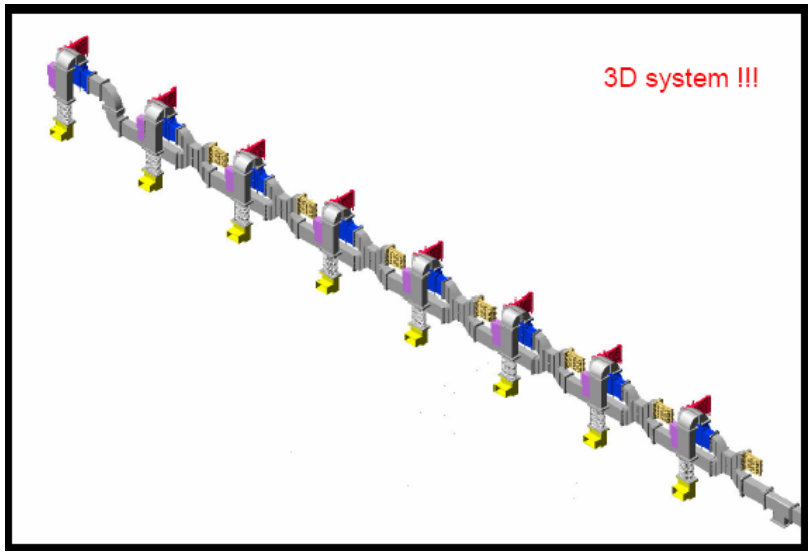


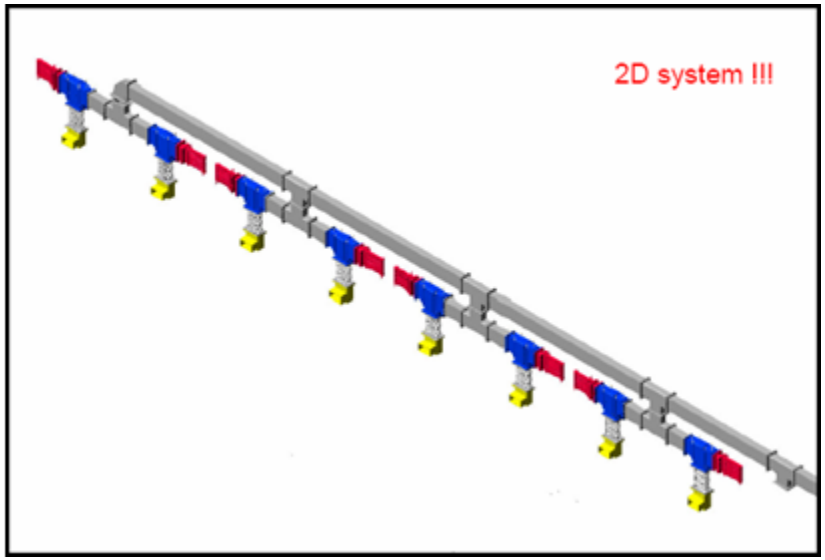
Dependence of efficiency on output power

Orders have been placed for all three manufacturers to deliver prototype of horizontal klystron suitable for tunnel installation

RF system cont'd

- A test of the 10 kV pulse cables (mainly concerning EMI issues) is in preparation (cable through FLASH tunnel)
- Two companies have been selected to deliver modulator prototype
- Simplified waveguide distribution system designed & built



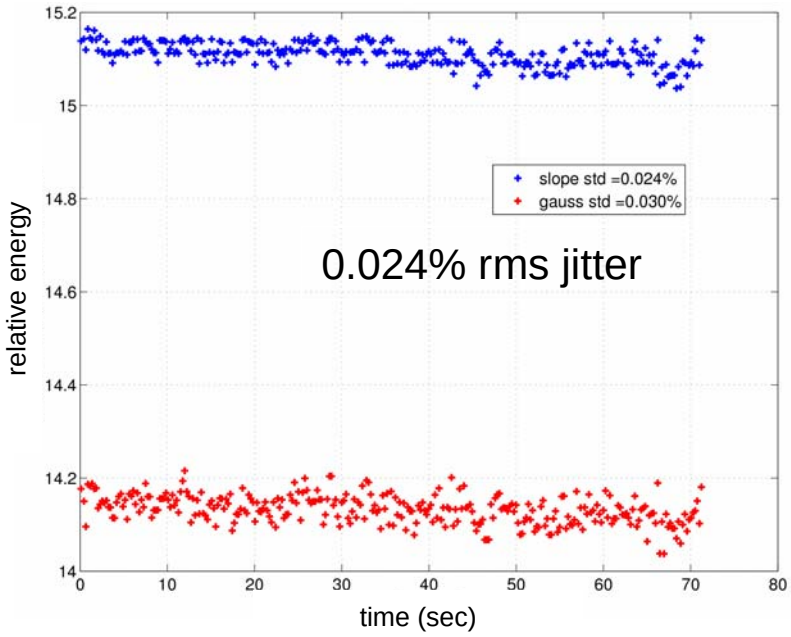


Progress on LLRF/energy stabilisation

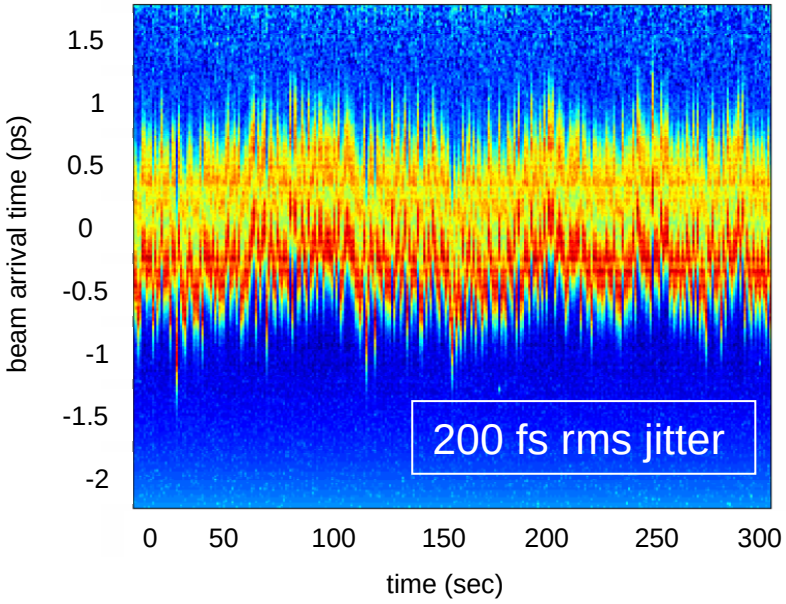
dE/E = 2.4 10^{-4} measured at 127 MeV

electron and FEL beam arrival time jitter 200 fs rms

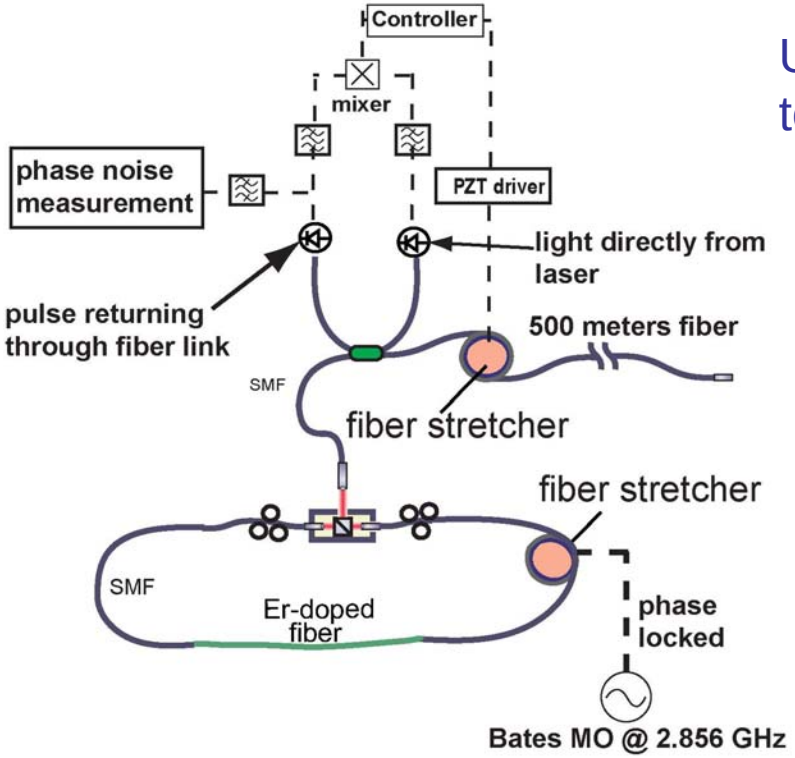
Energy jitter measured with synchrotron radiation monitor



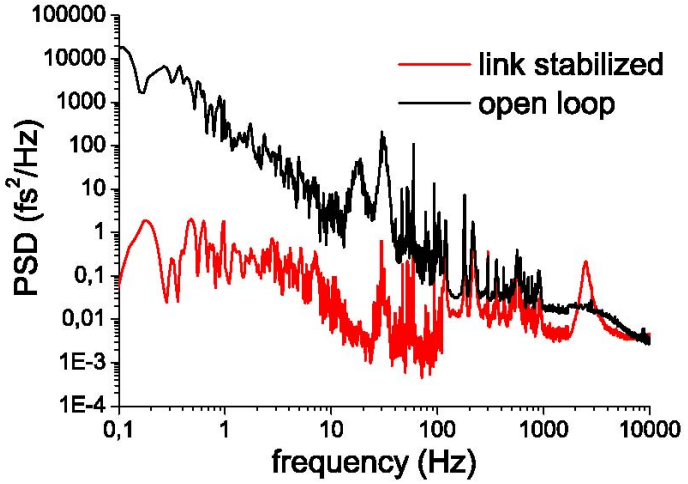
Beam arrival time measure with electro-optical decoding



Diagnostics, timing & synchronization in fs regime



Uni HH/DESY & MIT: 500m fiber link tested with 12fs noise level



Large amount of diagnostics development ongoing at FLASH (deflecting mode cav./slice diagn., EOS methods, arrival time detector,…)

Tunnel mock-up

- 50m long set-up with XFEL tunnel cross section
- Will test component transport & installation, undulator temperature stabilisation, etc.

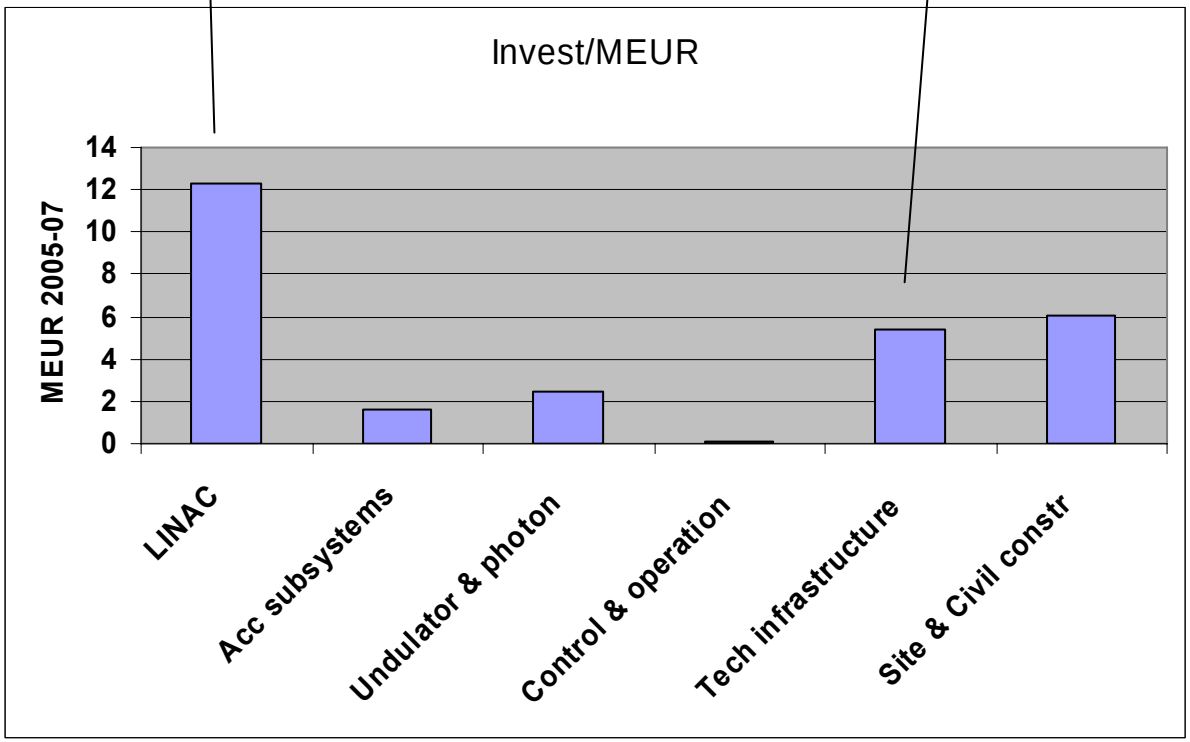
Project preparation expenses @ DESY y2005 - 07

Total invest ~28 MEUR

Personnel ~20 MEUR

~ 60% RF&LLRF, 40% s.c. tech

Mainly module test stand



The end