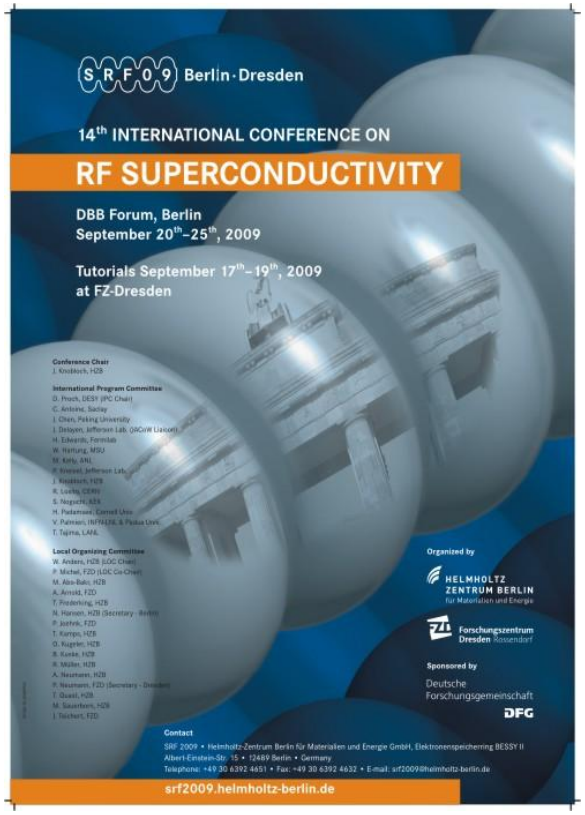
European XFEL



The European XFEL Based on Superconducting Technology

Hans Weise / DESY

DESY

HELMHOLTZ ASSOCIATION

a common project of many SRF experts sharing the responsibility for the superconducting linac

irfu cea saclay

INFN Istituto Nazionale di Fisica Nucleare

Universitas Studiorum Mediolanensis

cnrs dépasser les frontières In2p3

50 Lecie Instytutu Badań Jądrowych 1955-2005

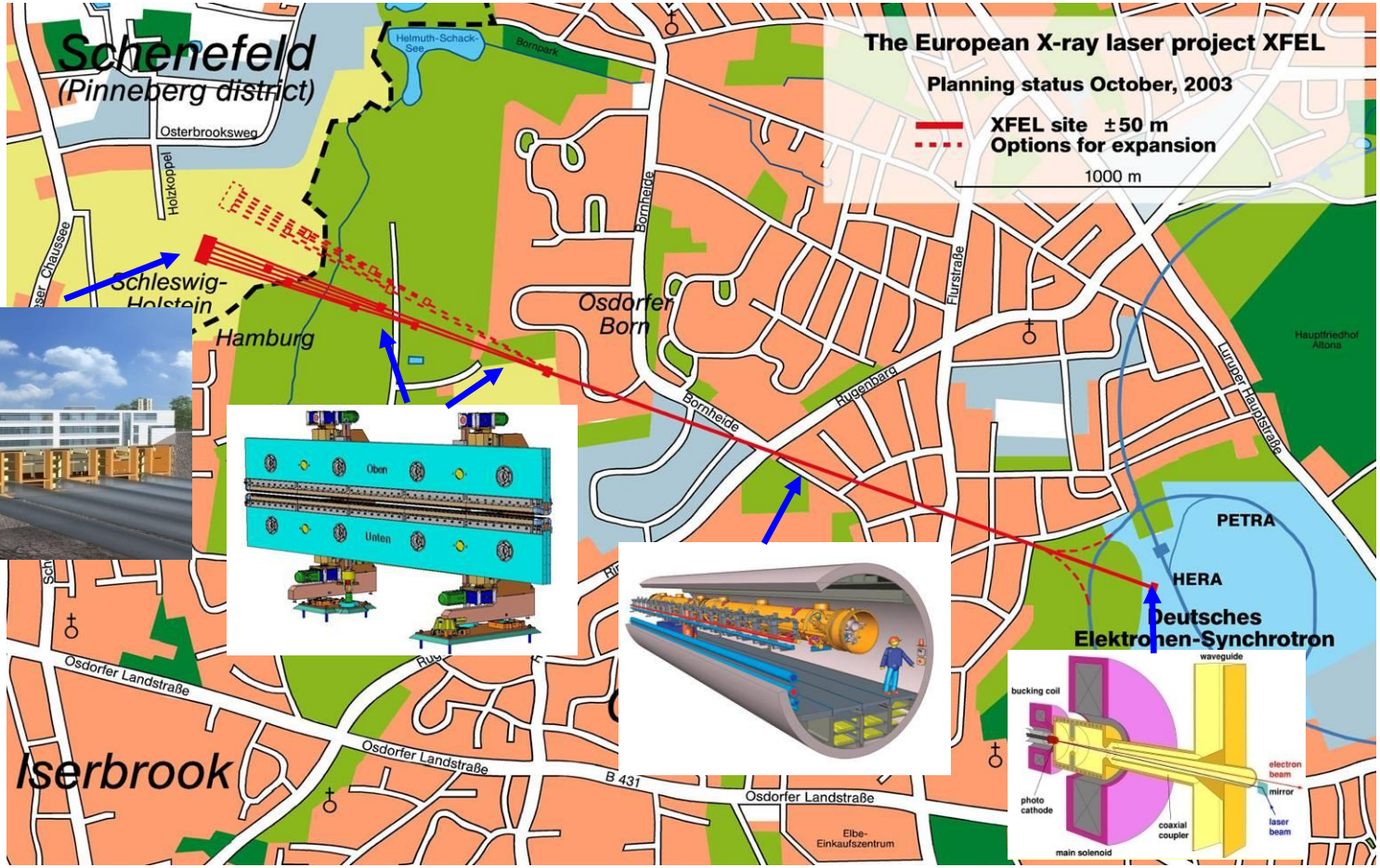
Ministerio de Educación y Ciencia

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Institute of High Energy Physics Chinese Academy of Sciences

Overall Layout of the European XFEL

3.4km

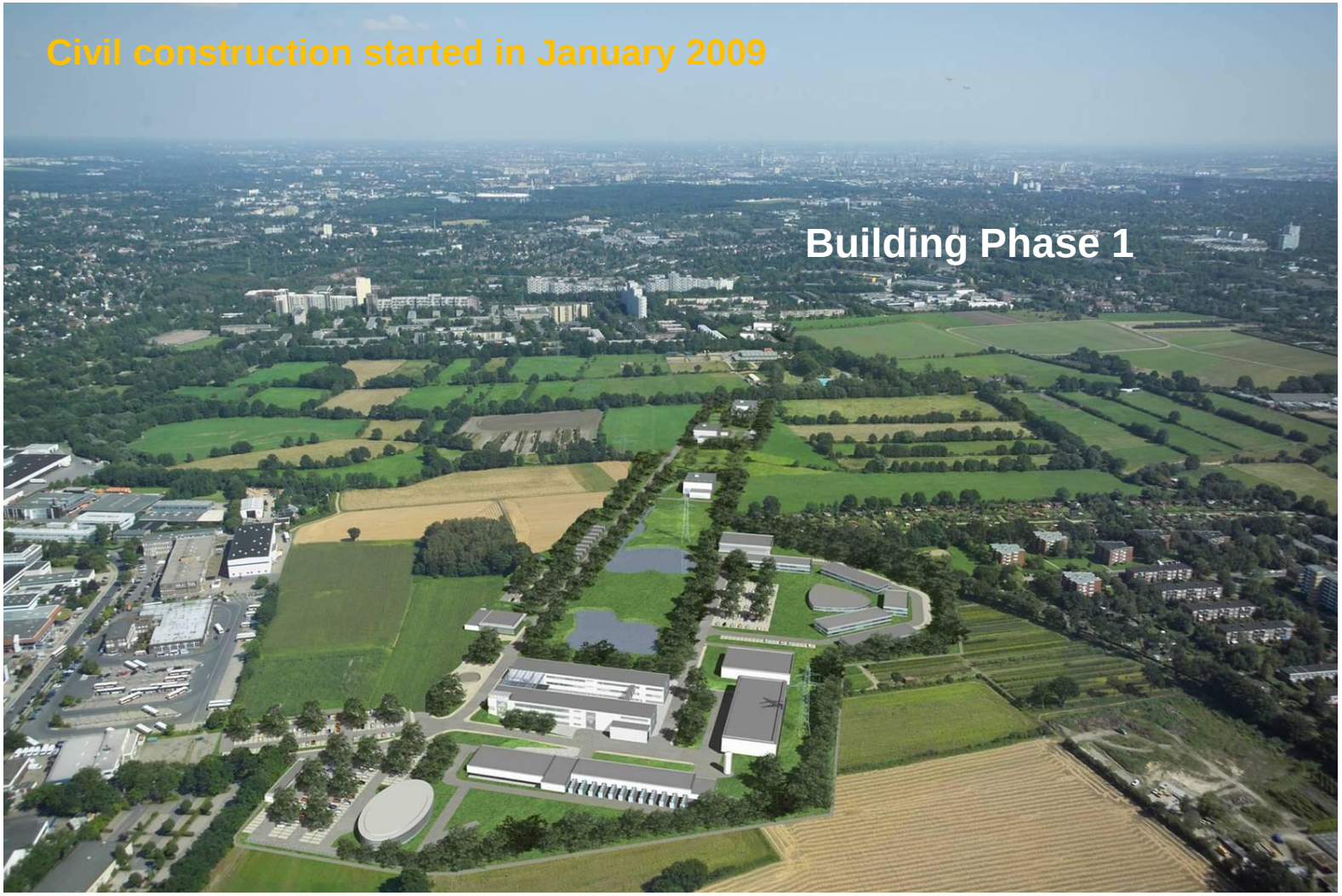


European XFEL

XFEL Site in Hamburg / Schenefeld

European XFEL

… after Construction (Computer Simulation)



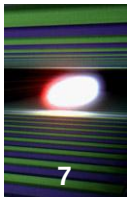
European XFEL

… during Construction (“the Real World”)

European XFEL

Civil Construction at all XFEL Sites

Civil Construction is of course not THE Issue..



It's 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?***

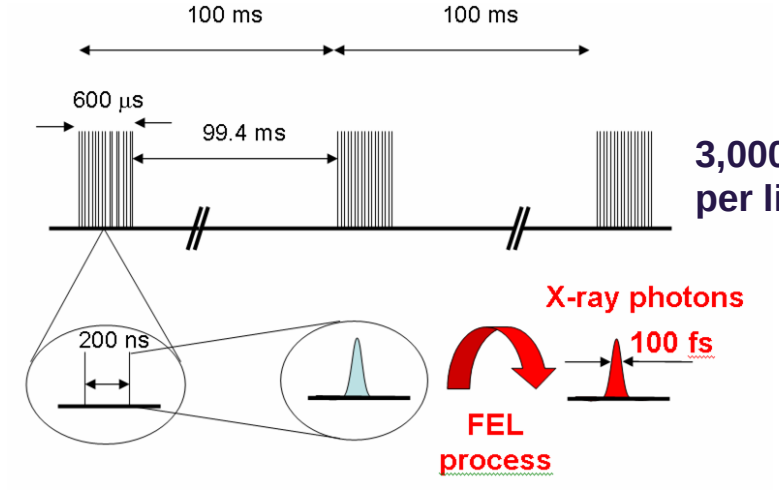
Soon X-ray free-electron lasers will enable us to probe ultra fast physical, chemical and biochemical processes at atomic resolution, opening new frontiers for science and technology.

Users say: At long last we may see, and not just model, how molecular machines really work.

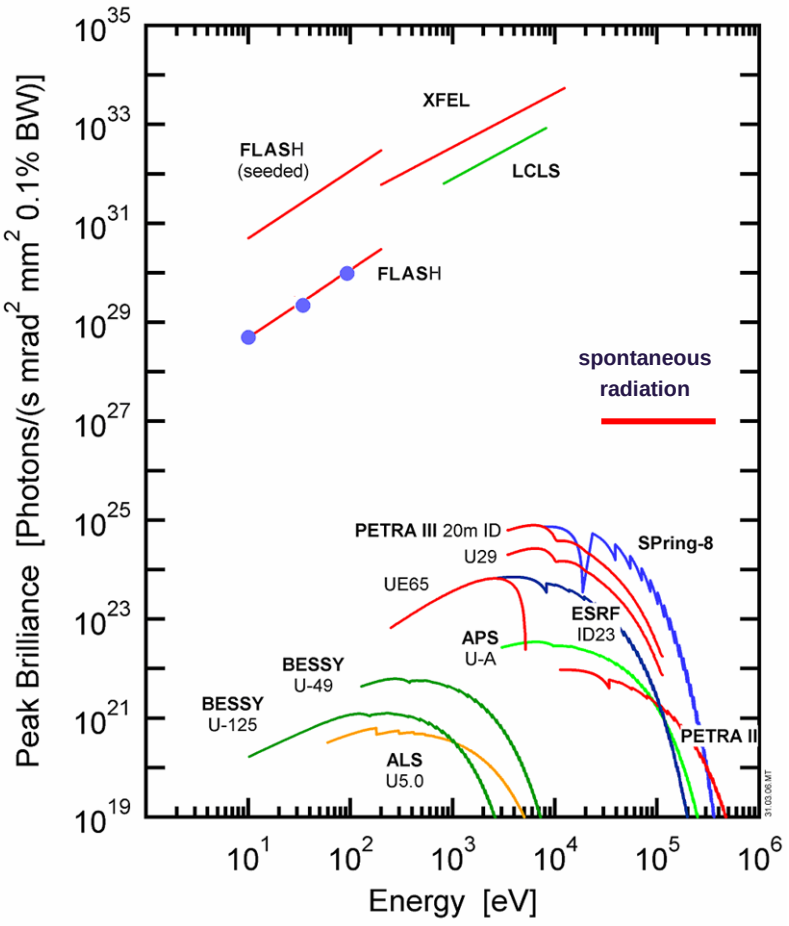
See http://xfel.eu for more on the enlightening science.

Properties of XFEL Radiation

- X-ray FEL radiation (0.2 - 12.4 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

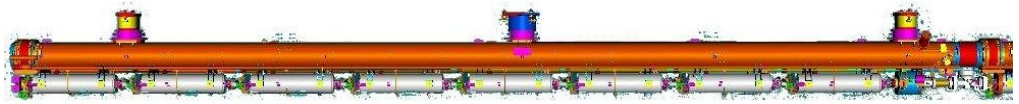


3,000 bunches per linac pulse



Accelerator Complex

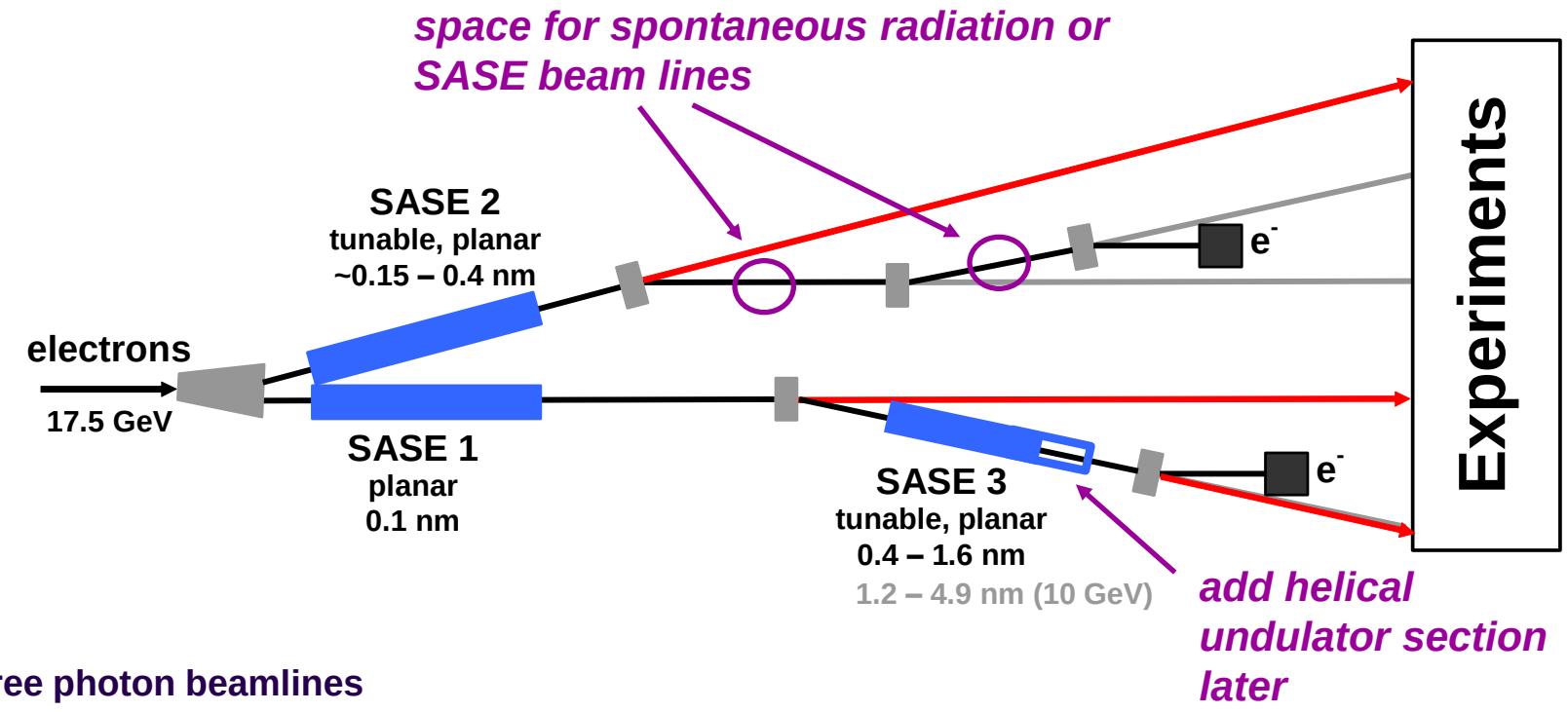
100 accelerator modules



800 accelerating cavities
1.3 GHz / 23.6 MV/m

25 RF stations
5.2 MW each

Beam Lines in Start Version

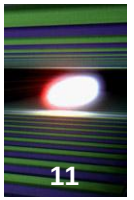


three photon beamlines

superconducting linac: 17.5 GeV

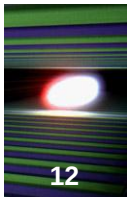
→ According to the XFEL TDR photon wavelengths below 0.1 nm design value require a linac gradient above 23.6 MV/m (design value)

LCLS Commissioning Results and Perspectives for the XFEL



- The **recent start-up of the LCLS** has been remarkably fast and successful and it has shown (besides the **excellence of the SLAC team**) that the **SASE process in the Ångstroem regime works robustly and as predicted**.
- Lasing depends on 6d phase space density; when optimizing the FEL performance, **pulse length** and **brilliance** of the photon pulse are the issue.
- The **parameter space leaves some options**; the discussion of X-ray FELs needs inclusion of shorter bunches at lower charge.
- **Safety margins in the XFEL design can be less conservative.** Based on a lower projected emittance (measured at DESY-PITZ) the **XFEL can reach shorter wavelength w/o any change in the facility layout.**
- Details are to be worked out and discussed with the respective committees (MAC & SAC).

Remarks to CW Operation

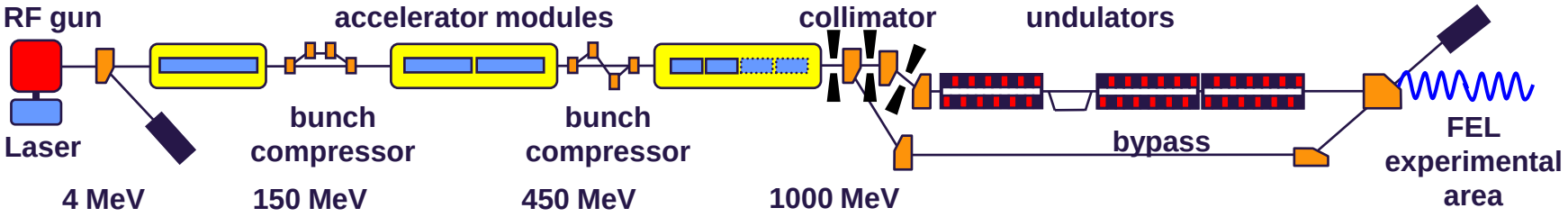


- The XFEL is the only X-ray Free-Electron Laser which can be operated cw.
- We are **keeping the option open** and closely follow and support R&D on injectors. *(talk MOOBAU03 poster TUPPO001)*
- The necessary replacement of klystrons by **IOTs** seems to be possible; infrastructure is not the big issue.

EUROFEL-Report-2007-DS5-074

- **A rough estimate** wrt. needed resources including additional effort for undulators shows that of the order of 20% of the initial investment might be required.
- Summary: If the technology is available and the user case is well developed, the already very attractive XFEL can be made even more attractive, i.e. **cw operation might become available in an attractive upgrade scenario**.

The FLASH Facility at DESY



- **6 accelerator modules** routinely in operation; design beam energy & photon wavelength (6.5 nm) since Oct. 2007
- **pilot facility** regarding practically all aspects (accelerator technology, beam physics, FEL process, user operation) of the XFEL

European XFEL

XFEL Accelerator Module Prototypes

Institute of High Energy Physics
Chinese Academy of Sciences

duro felguera, s.a.

THALES

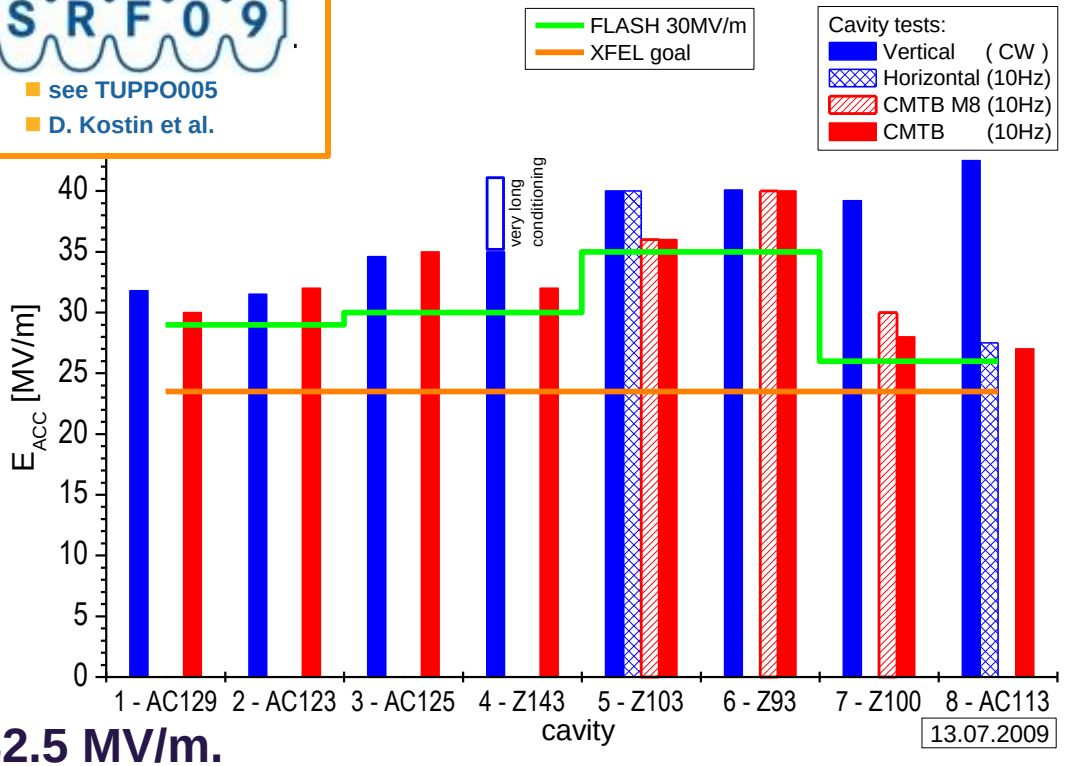
DESY HELMHOLTZ ASSOCIATION

European XFEL

PXFEL1 - The *Chinese* Module at CMTB

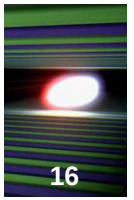
SRF09

- see TUPPO005
- D. Kostin et al.



- The accelerator module PXFEL1 was conditioned and tested at the Cryo-Module Test Bench (CMTB).
- The average maximum gradient is **32.5 MV/m.**
- After string and module installation we have seen a **gradient reduction of only 5%.**
- PXFEL1 will be installed at FLASH and **can be operated** there with an average gradient of **30 MV/m.**
- The **XFEL waveguide distribution** will be used.

Lesson Learned from Module #8

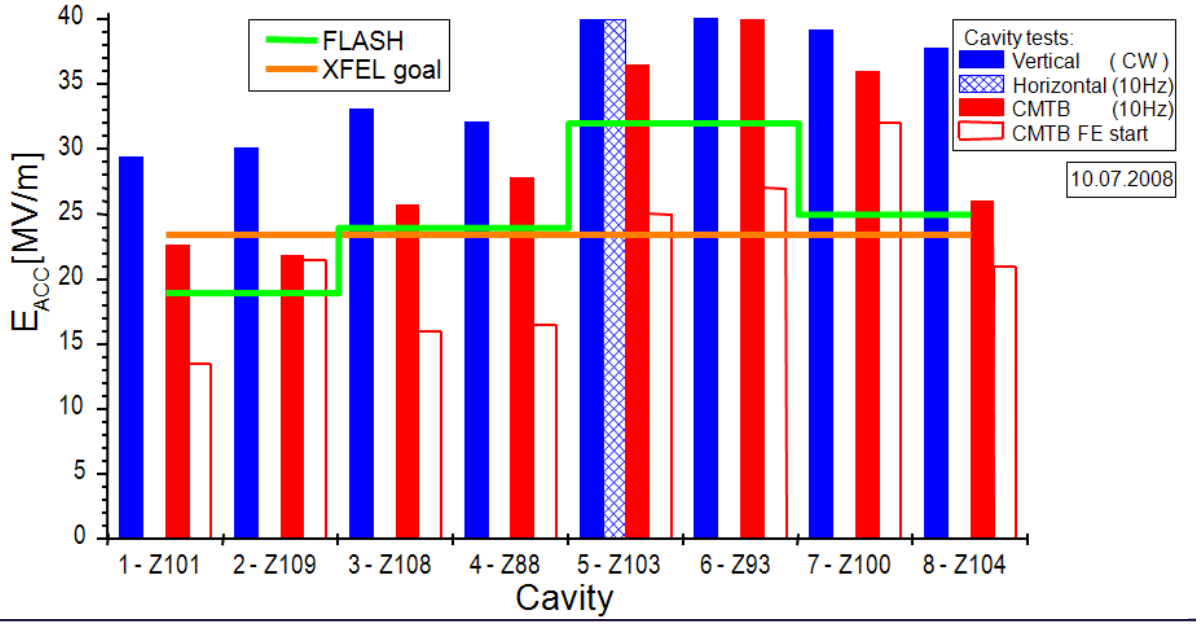


- Module 8 was the **test vehicle for an out-sourced module assembly.**
- Two groups of four cavities each were assembled by **two different teams.**
- **Findings:**
  - The actual work was done with slightly different ‚respect'.
  - But we were unable to identify or describe obvious differences.
  - There was the suspicion that the single cavity venting was done with either different care or just different due to an aged venting equipment.
- **Consequences:**
  - All assembly steps were carefully checked.
  - The venting system was replaced.

SRF09
- see THPPO099
- L. Lilje et al.

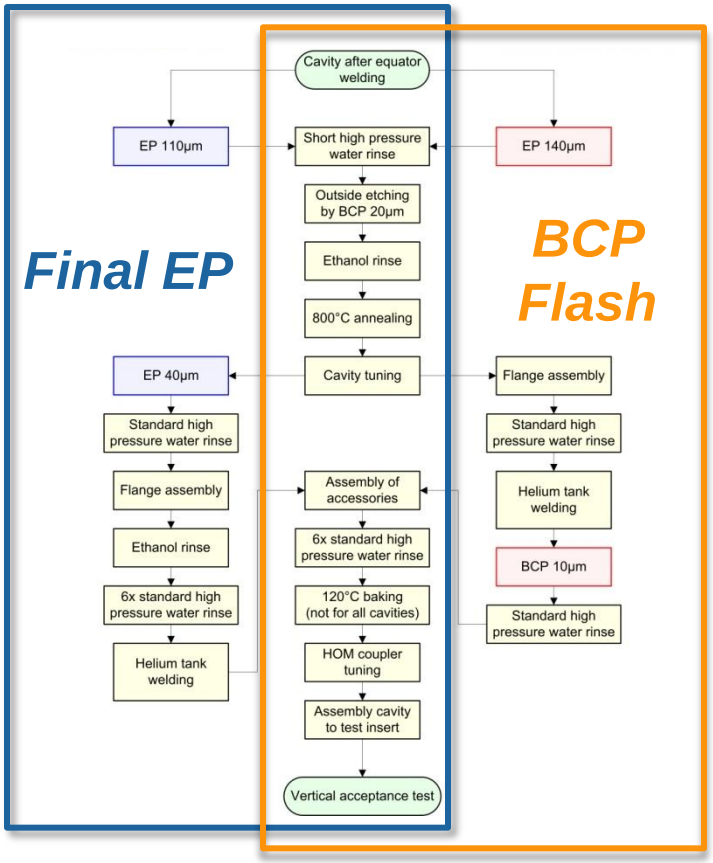
- **Result:**

see PXFEL1 (previous slide).



Cavities

- **Two schemes** for the final surface treatment (***Final EP*** and ***BCP Flash***) were studied with **cavities from two different vendors**.
- The **preparation strategy** to go for a final treatment with the cavity already welded into the He-vessel was investigated.



- **Results** are:
  - yield curves for the different schemes
  - yield curves for the different vendors
  - a preparation strategy
  - a strategy for the call for tender

SRF09
- see THPPO072
- B. van der Horst et al.

preparation cycle

SRF09
- see TUPPO050
- D. Kostin et al.

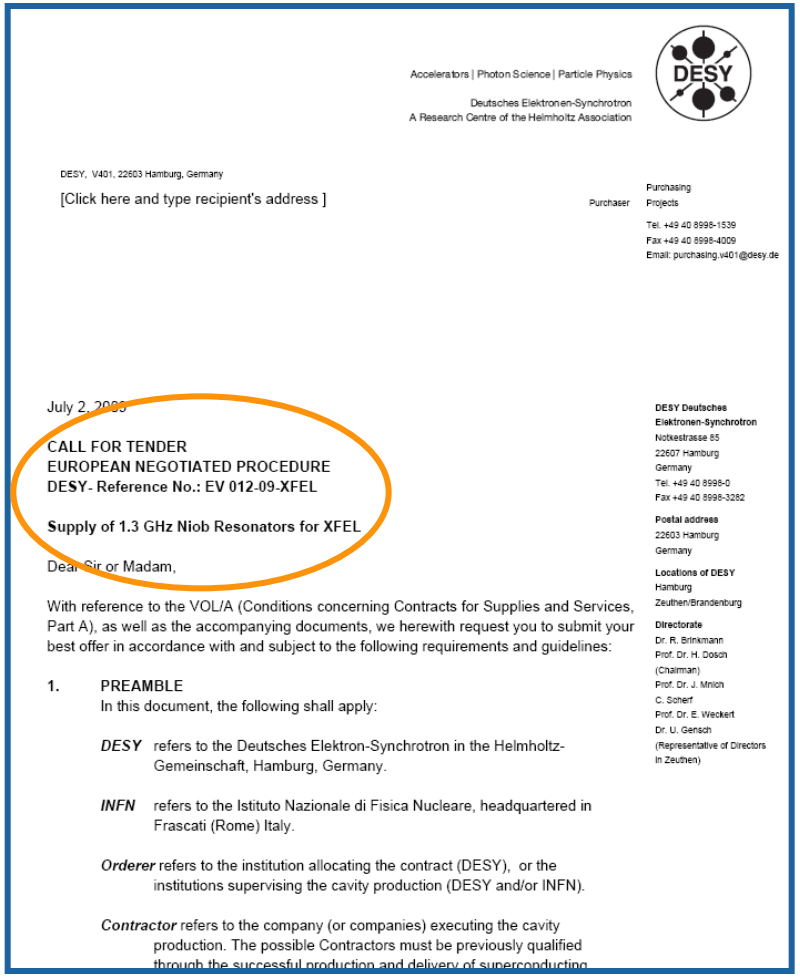
9-cell cavity cw tests

SRF09
- see TUPPO051
- D. Reschke et al.

analysis of recent 9-cell cavity tests

European XFEL

Cavity cont'd



Accelerators | Photon Science | Particle Physics

Deutsches Elektronen-Synchrotron
A Research Centre of the Helmholtz Association

DESY, V401, 22603 Hamburg, Germany

[Click here and type recipient's address]

Purchaser

Purchasing
Projects

Tel. +49 40 8998-1539
Fax +49 40 8998-4009
Email: purchasing.v401@desy.de

July 2, 2009

CALL FOR TENDER
EUROPEAN NEGOTIATED PROCEDURE
DESY- Reference No.: EV 012-09-XFEL

Supply of 1.3 GHz Niob Resonators for XFEL

Dear Sir or Madam,

With reference to the VOL/A (Conditions concerning Contracts for Supplies and Services, Part A), as well as the accompanying documents, we herewith request you to submit your best offer in accordance with and subject to the following requirements and guidelines:

1. PREAMBLE
In this document, the following shall apply:

DESY refers to the Deutsches Elektron-Synchrotron in the Helmholtz-Gemeinschaft, Hamburg, Germany.

INFN refers to the Istituto Nazionale di Fisica Nucleare, headquartered in Frascati (Rome) Italy.

Orderer refers to the institution allocating the contract (DESY), or the institutions supervising the cavity production (DESY and/or INFN).

Contractor refers to the company (or companies) executing the cavity production. The possible Contractors must be previously qualified through the successful production and delivery of superconducting

DESY Deutsches Elektronen-Synchrotron
Notkestrasse 85
22607 Hamburg
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Fax +49 40 8998-3282

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22603 Hamburg
Germany

Locations of DESY
Hamburg
Zeuthen/Brandenburg

Directorate
Dr. R. Brinkmann
Prof. Dr. H. Dosch
(Chairman)
Prof. Dr. J. Mnich
C. Scherf
Prof. Dr. E. Weckert
Dr. U. Gensch
(Representative of Directors in Zeuthen)

- Cavity **Call for Tender was published** on July 2nd, 2009.
- **Production and preparation** in industry.
- Contract to be allocated by DESY.
- Supervision of cavity production by DESY and INFN.
- Details can be published only 6 months after contracts are placed.

RF Measurement for XFEL Cavity Production

way to go

- Prototype was successfully used for the recent cavity production.
- **Considerably shorter tuning time.**
- Automation and documentation.
- Minor changes required for industrial use.
- Two more machines under fabrication.

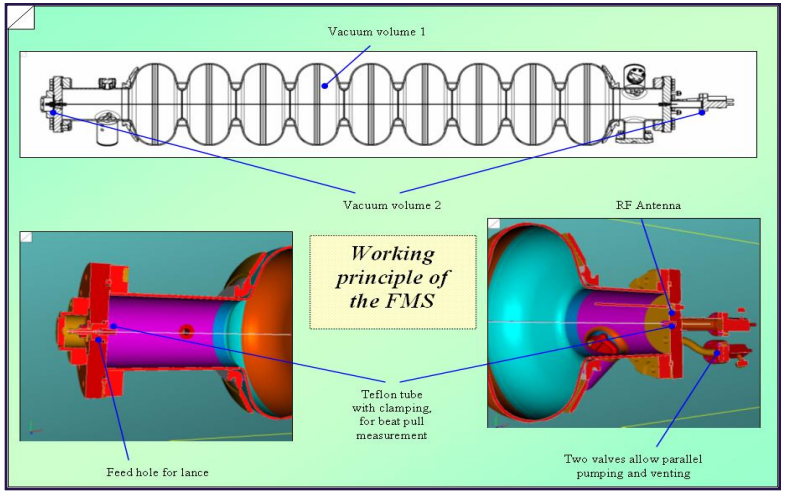
SRF09

- see THPPO071
- J. Iversen et al.

RF measurement

Helium Vessel Welding

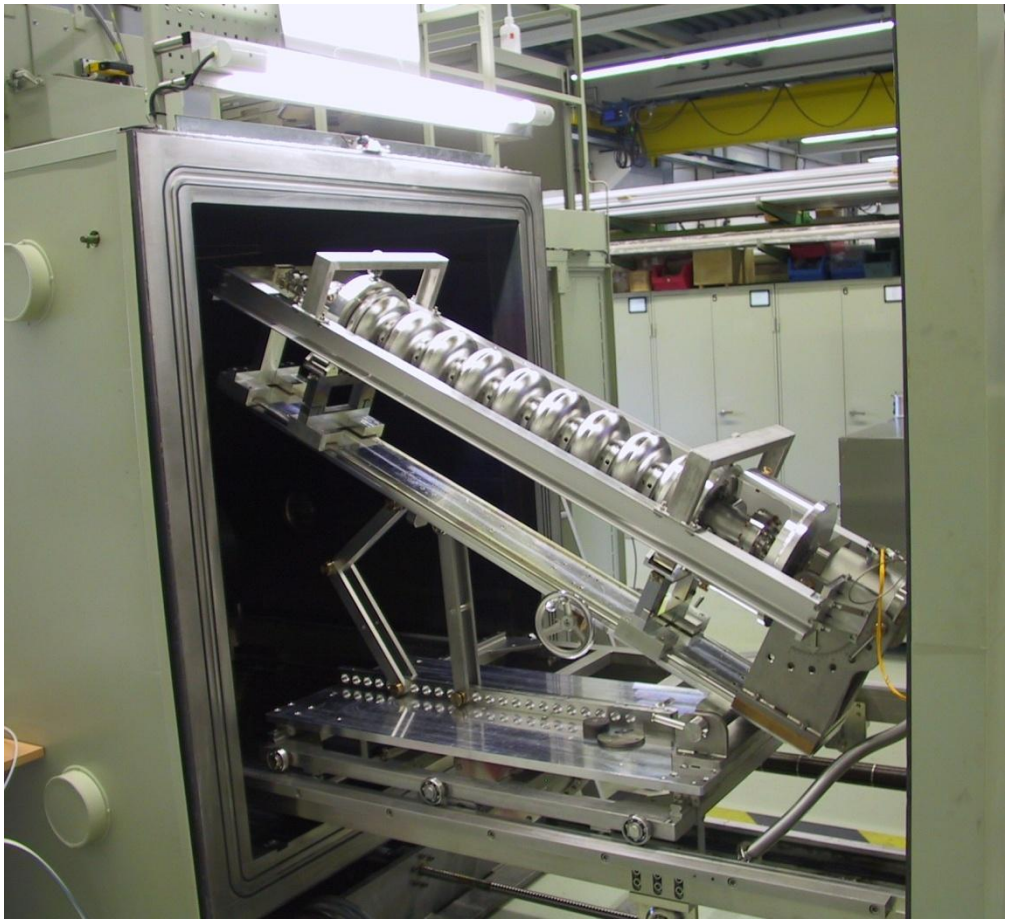
- The optimized preparation procedure requires tank welding after the *Final EP*.
- The field profile needs to be measured, i.e. a bead bull is to be done under clean conditions.



SRF09

- see THPPO040
- A. Schmidt

Helium tank welding



- *DESY EB plant with cavity prepared for ring welding*

Tuning Machine

- **Two machines** for series cavity production are under commissioning at DESY.
- Development of software and electronic devices done at FNAL.
- CE certification of the entire machine according to European rules and laws.
- Machine **can be operated by Non-RF-Experts**!

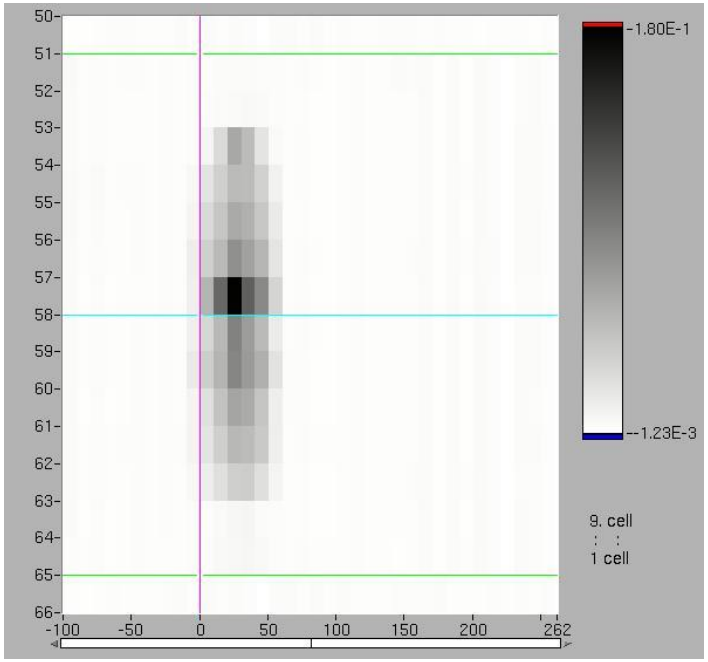
SRF09

- see THPPO074
- J.-H. Thie et al.

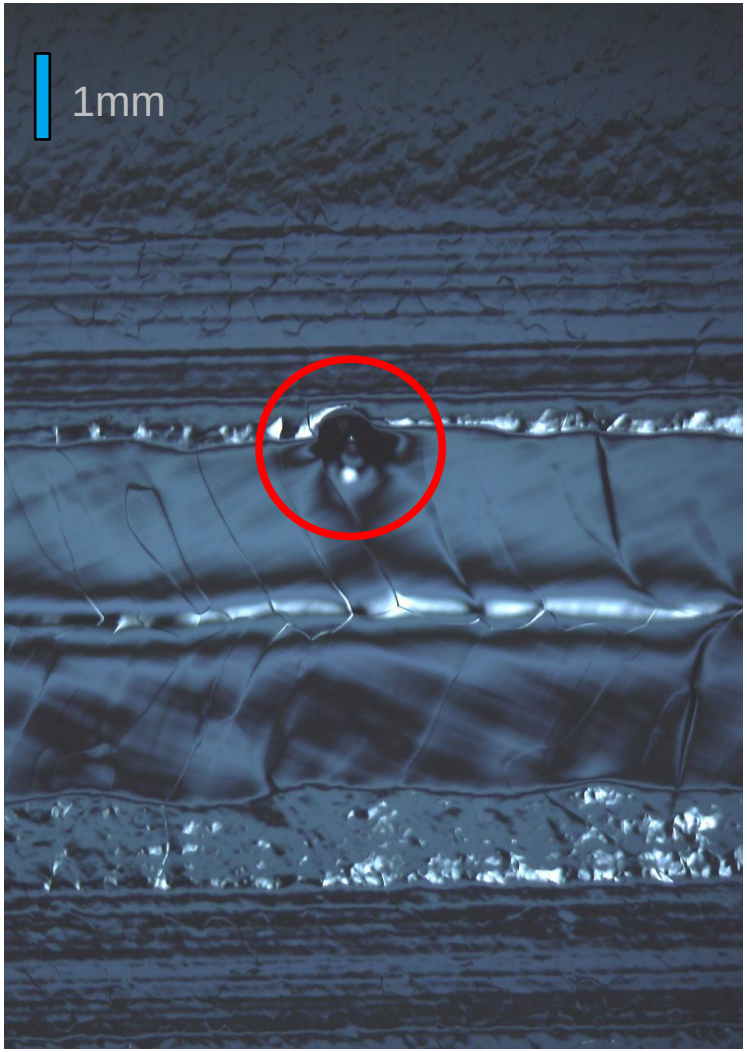
automatic cavity tuning machine

Surface Inspection of Cavity Z130

- Hot spot found by temperature mapping at equator 5 in 3pi/9-mode.



- Heat affected zone around equator.



- Picture taken at same location.

SRF09
- see TUPPO035
- S. Aderhold et al.

optical inspection

SRF09
- see TUPPO073
- W. Singer et al.

surface investigation of samples extracted from prototype cavities

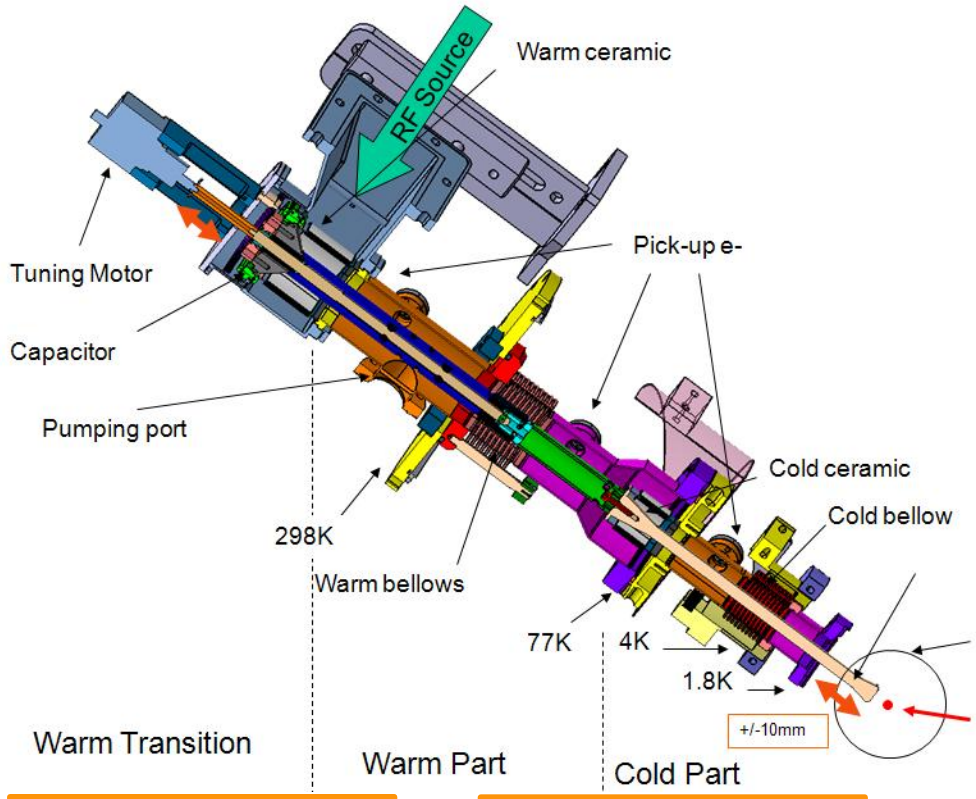
European XFEL

Cavity String & Module Assembly

Using experience gained at DESY and results of industrial studies, the assembly facility for all 100 XFEL modules will be set up at the CEA-Saclay site.

CEA (IRFU), CIEMAT, DESY, INFN-Milano, LAL Orsay, Swierk take the responsibility for the cold linac.

XFEL RF Power Coupler



SRF09

- see THPPO038
- A. Goessel et al.

RF Conditioning of power couplers

SRF09

- see THPPO039
- S. Kotthoff et al.

Remote controlled XFEL coupler interlock

- **LAL Orsay** has taken over the responsibility for the XFEL RF power **coupler production**.
- **Conditioning** of the couplers will take place at LAL Orsay.
- The **coupler interlock** system was developed and will be **contributed by DESY.**

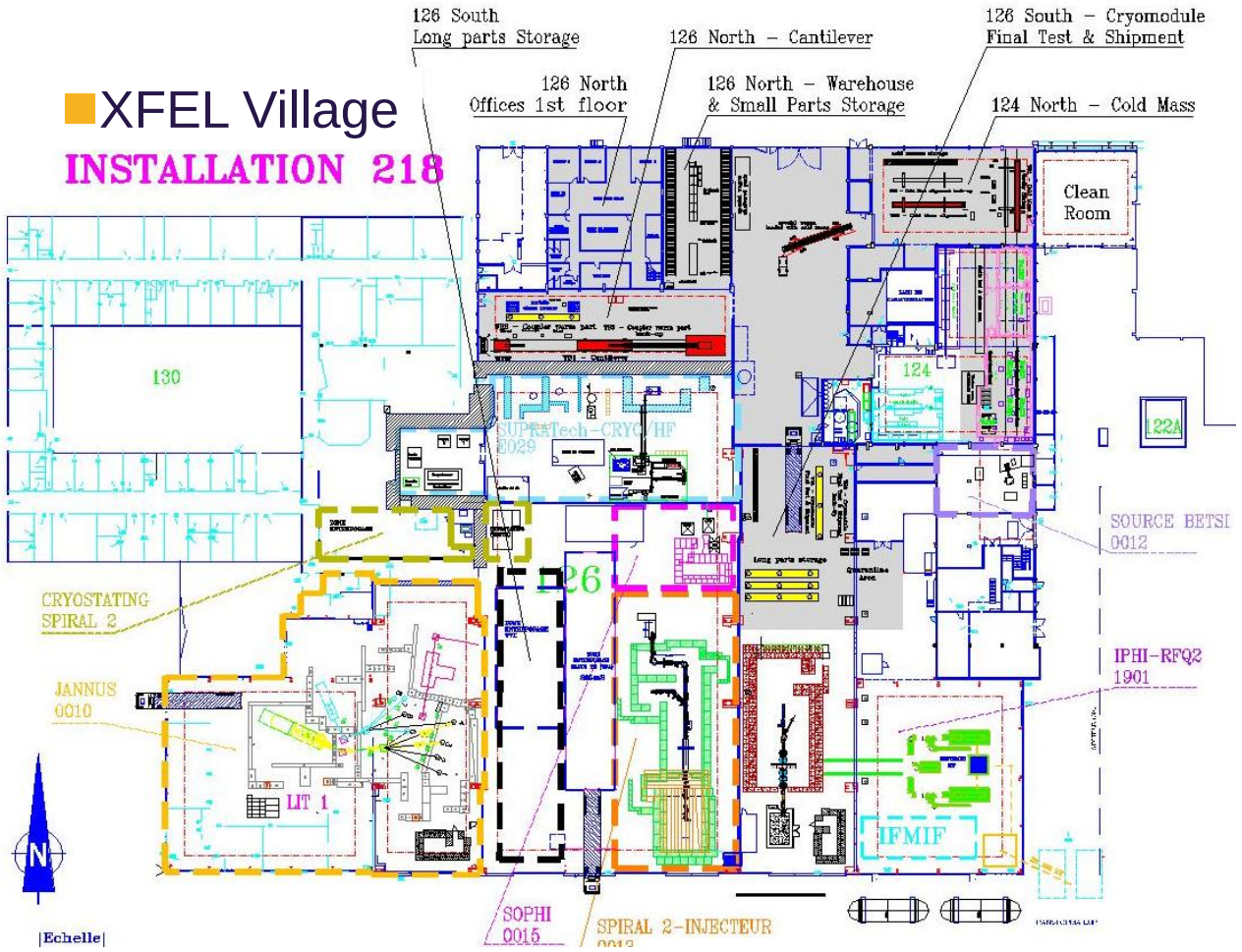
XFEL RF Power Coupler

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

- Max. RF Power of **5 MW**.
- Conditioning rate of **8 couplers per week**.
- Either pairs (4 x 2 couplers) or units of 4 couplers (under study).
- Schedule integrated in overall project schedule.

- Direct delivery to assembly site at CE Saclay.

Infrastructure for Module Assembly



irfu
cea
saclay

- A complete design and cost estimate for the civil engineering and general equipments was done; construction has started (see next slides).

European XFEL

Infrastructure for Module Assembly

irfu

cea

saclay

DESY

HELMHOLTZ ASSOCIATION

European XFEL

Infrastructure for Module Assembly

irfu

cea

saclay

DESY

HELMHOLTZ ASSOCIATION

European XFEL

Accelerator Module #8 - Transport

European XFEL

Accelerator Modules - Transportation Tools

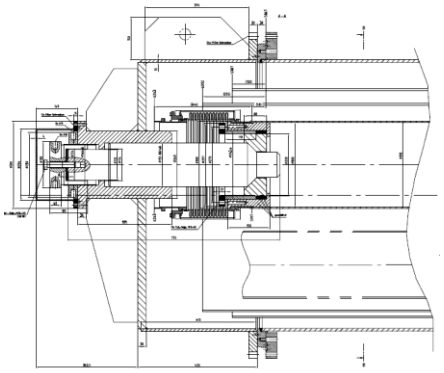
irfu

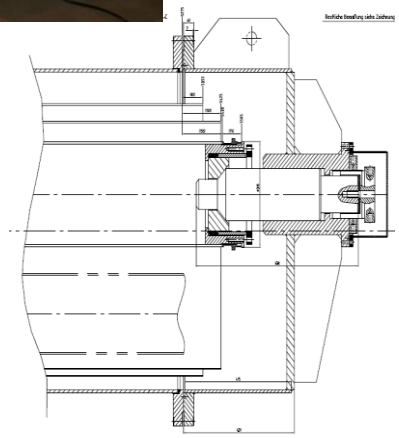
cea

saclay

HELMHOLTZ GEMEINSCHAFT DESY

INFN-LASA

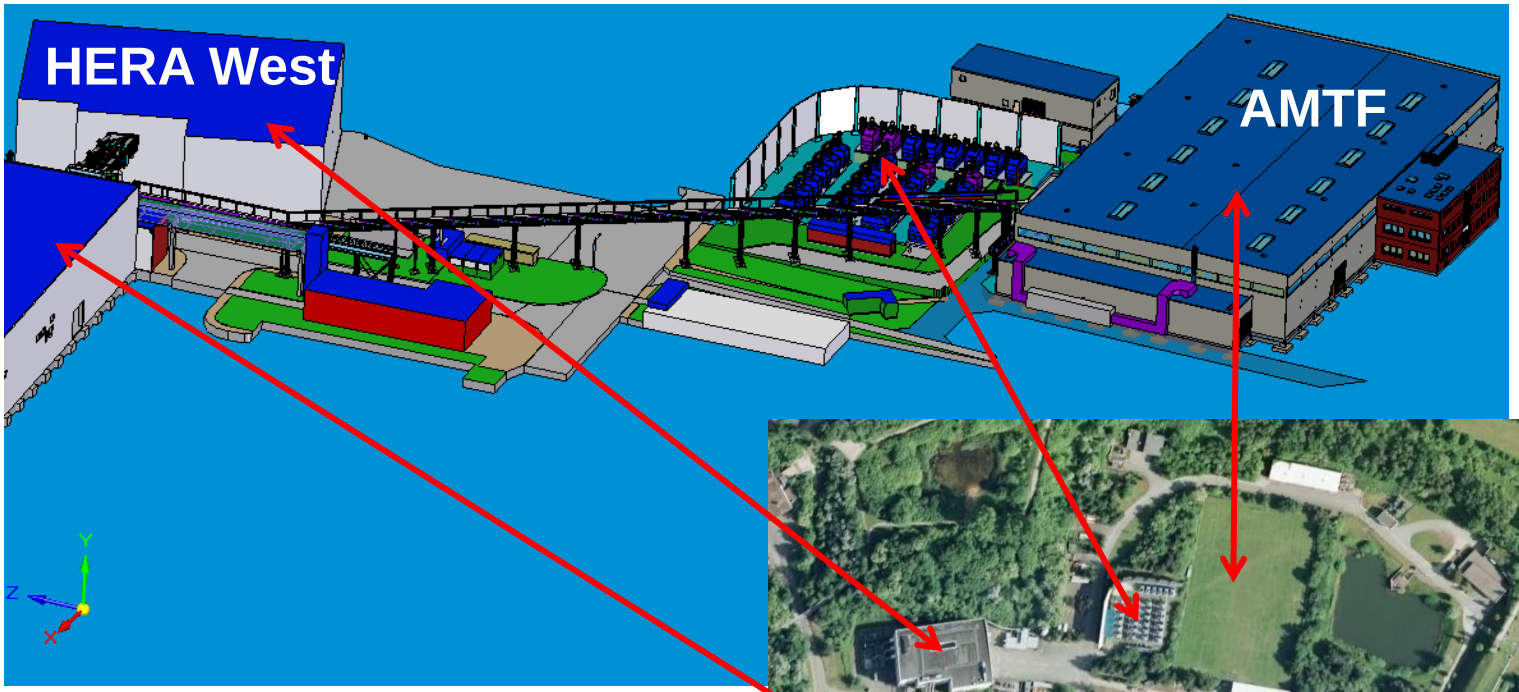


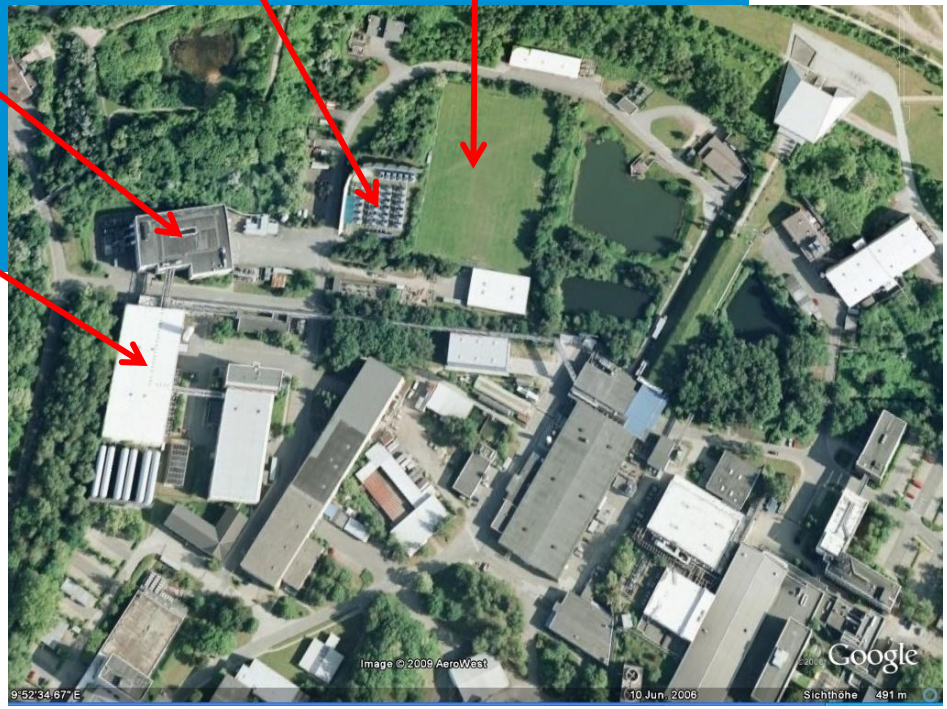


- Feed-cap side
- End-cap side

DESY HELMHOLTZ ASSOCIATION

Accelerator Module Test Facility (AMTF) Including Single Cavity Tests



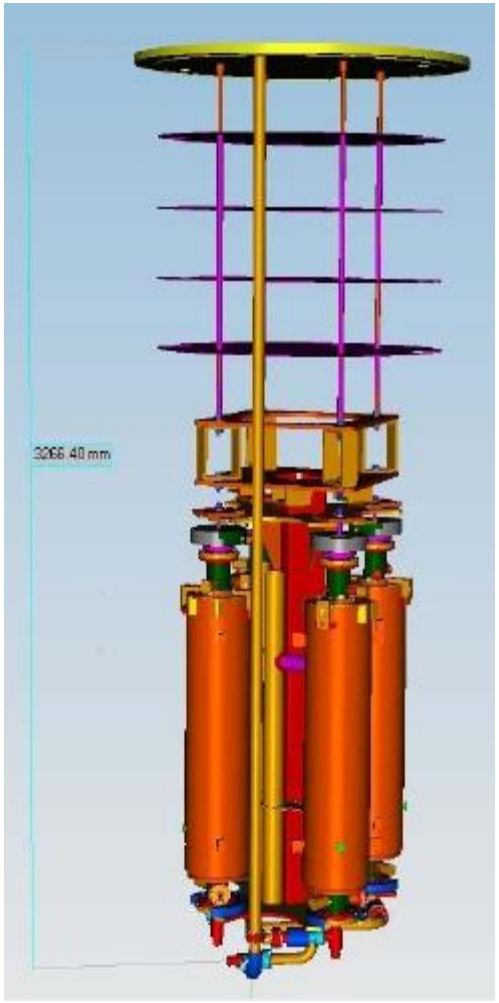


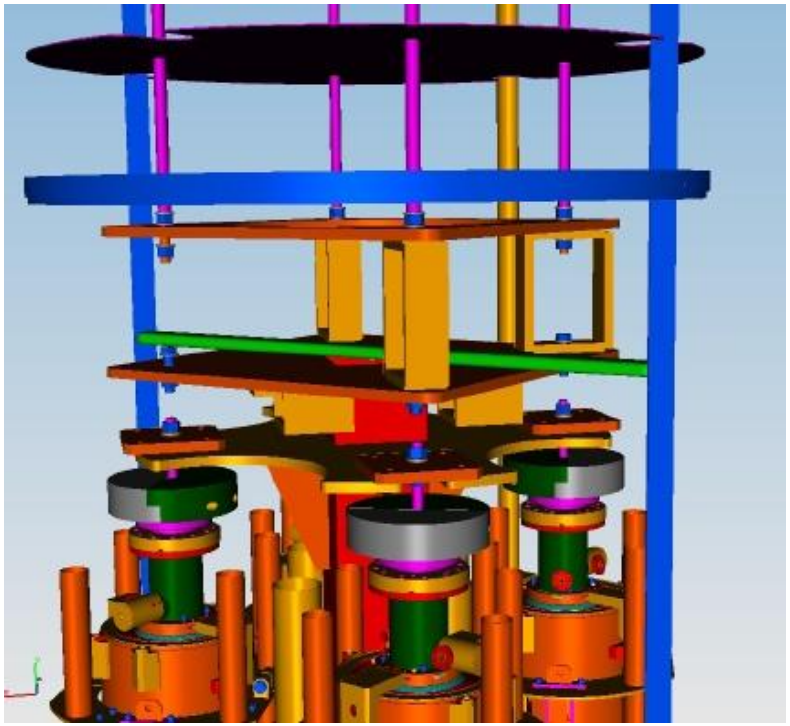
- First cavity tests required for 1/2011
- Commissioning of module test facility 4/2011
- AMTF ready for infrastructure installation 3/2010

European XFEL

Accelerator Module Test Facility (AMTF)

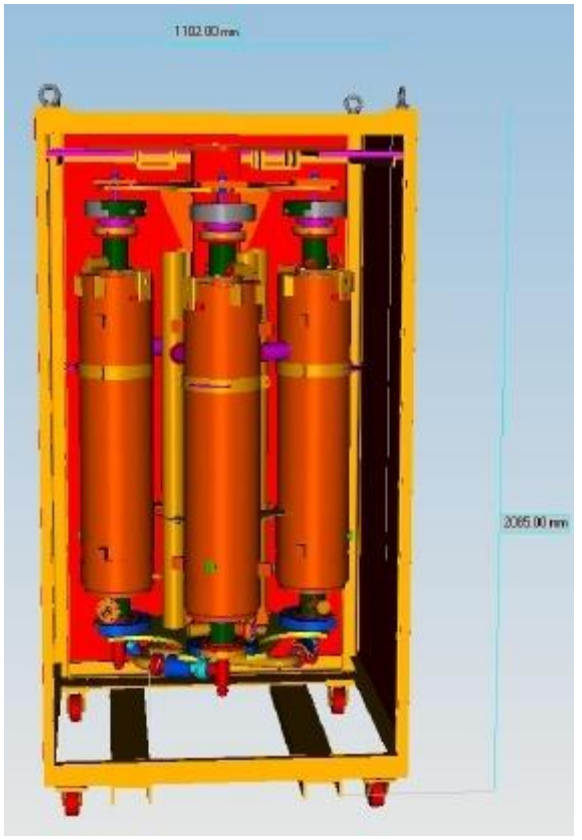
Cavity Tests at AMTF Starting in 2011



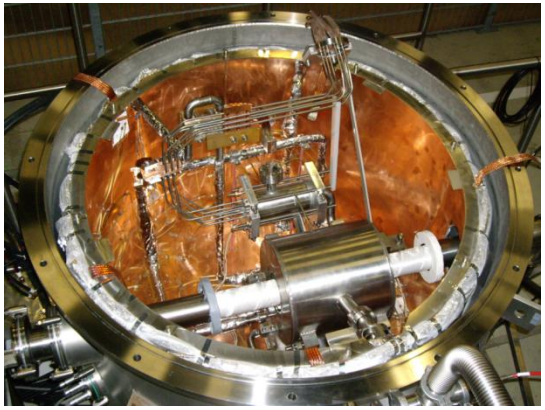


- Transportation frame; actual design, tests with single cavities on-going

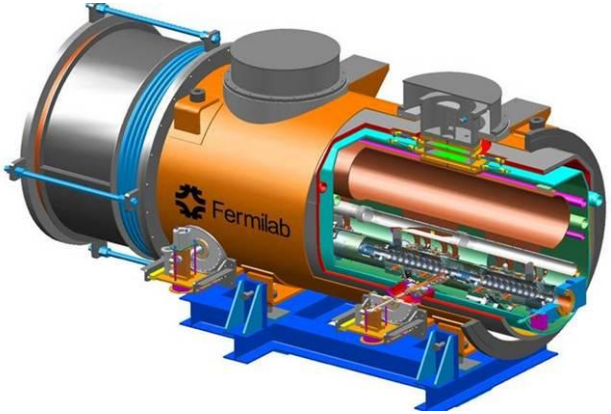
- 4-cavity insert for AMTF test cryostats; design ready, construction a.s.a.p.



Many More Components, e.g. Cold Magnets, 3.9 GHz Acceleration, RF Systems …



- The first **cold magnet** in the test cryostat.



- The **3.9 GHz** accelerator module delivered in spring 2009.

Test stand @ DESY, Zeuthen

- **RF system** R&D at DESY.

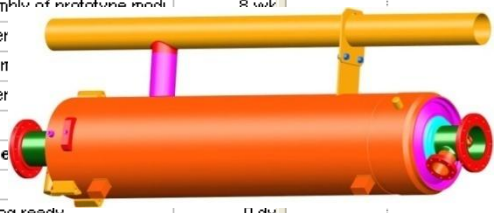
European XFEL

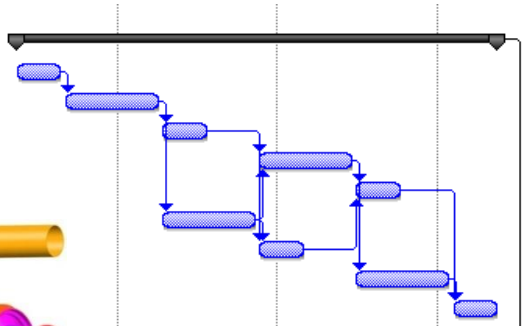
Dedicated XFEL Cold Linac Meetings

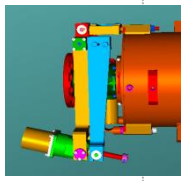
schedules … schedules …schedules

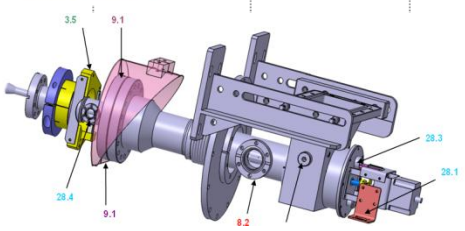
Gantt Chart

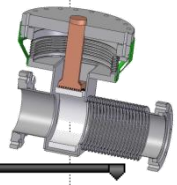
34		WP3/9 out PM in	string and module assembly training	200 dy
35			initial training of new assembly teams	4 wk
36			1st dis- and re-assembly of prototype modu	8 wk
37			CMTB test of re-assembled prototype #1	4 wk
38			2nd dis- and re-assembly of prototype modu	8 wk
39			CMTB test of re-assembled prototype #1	4 wk
40			1st dis- and re-assembly of prototype modu	8 wk
41			CMTB test of re-asser	
42			2nd dis- and re-assen	
43			CMTB test of re-asser	
44				
45			pre-series module asse	
46		WP03 out PM in	pre-series module #1	
47		WP09 out WP03 in	first pre-series string ready	0 dy
48		WP03 out PM in	pre-series module #2	7 wk
49		WP09 out WP03 in	second pre-series string ready	0 dy
50		WP03 out PM in	pre-series module #3	7 wk
51		WP09 out WP03 in	third pre-series string ready	0 dy
52			start CMTB module testing	60 dy
56				

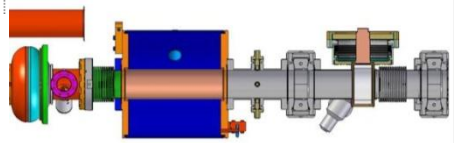












- We followed the goal of developing **one common schedule** with all necessary **links between the individual cold linac work packages.**
- Although we are still heavily loaded with planning and administrational issues, **technical aspects produce a lot of fun.**

Collaborative Effort and Collaborative Design

The European X-Ray Laser Project XFEL X-Ray Free-Electron Laser

What is Collaborative Design?

- complex facilities are developed via the interaction of many, sometimes thousands of participants, who are working concurrently on different elements of the design
- collaborative design aims to provide a systematic approach for integrating their design contributions
  - aiming to converge on a single design that is acceptable to all participants
- a complete product design includes the requirements on the product, the specification[1] of the product, and the processes[2] for mastering the product through its lifecycle
  - [1]specification includes geometry, materials, properties, behavior
  - [2]processes: e.g. manufacturing, operation, maintenance support

compiled from input of various sources of literature

T. Hott, L. Hagge: Report from the 1st Workshop on the XFEL Collaborative Design Effort
22.10.2008

DESY HELMHOLTZ GEMEINSCHAFT 24

- coordination issues
- project management
- standards
- use of centrally offered methods and tools

Collaborative Effort

Many thanks to:

- Work Package Leaders and Co-Leaders.
- THE experts.

SRF09

- see xxxx
- yyyy et al.

quite a few more XFEL related presentations

The end