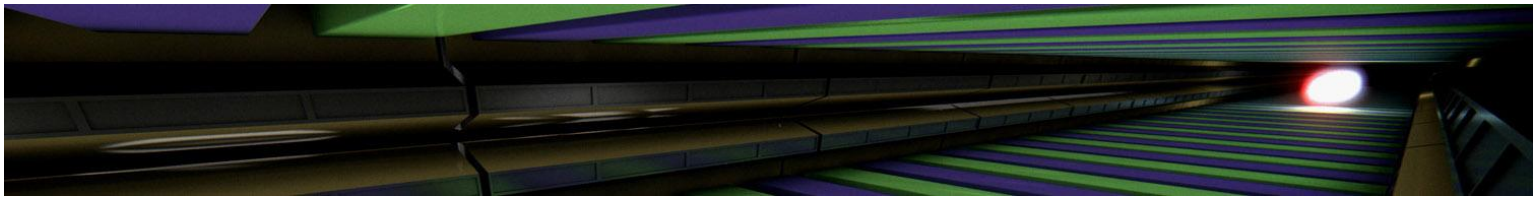
European XFEL



XXV LINEAR ACCELERATOR CONFERENCE
LINAC10
TSUKUBA, JAPAN
SEPTEMBER 12 - 17, 2010

Status of the European XFEL

MO102 - Hans Weise / DESY

DESY

HELMHOLTZ ASSOCIATION

European XFEL

The Cutter Head

DESY HELMHOLTZ ASSOCIATION

Tunnel and Borer Christening Ceremony

- Saint Barbara, Patroness of the Miners

European XFEL

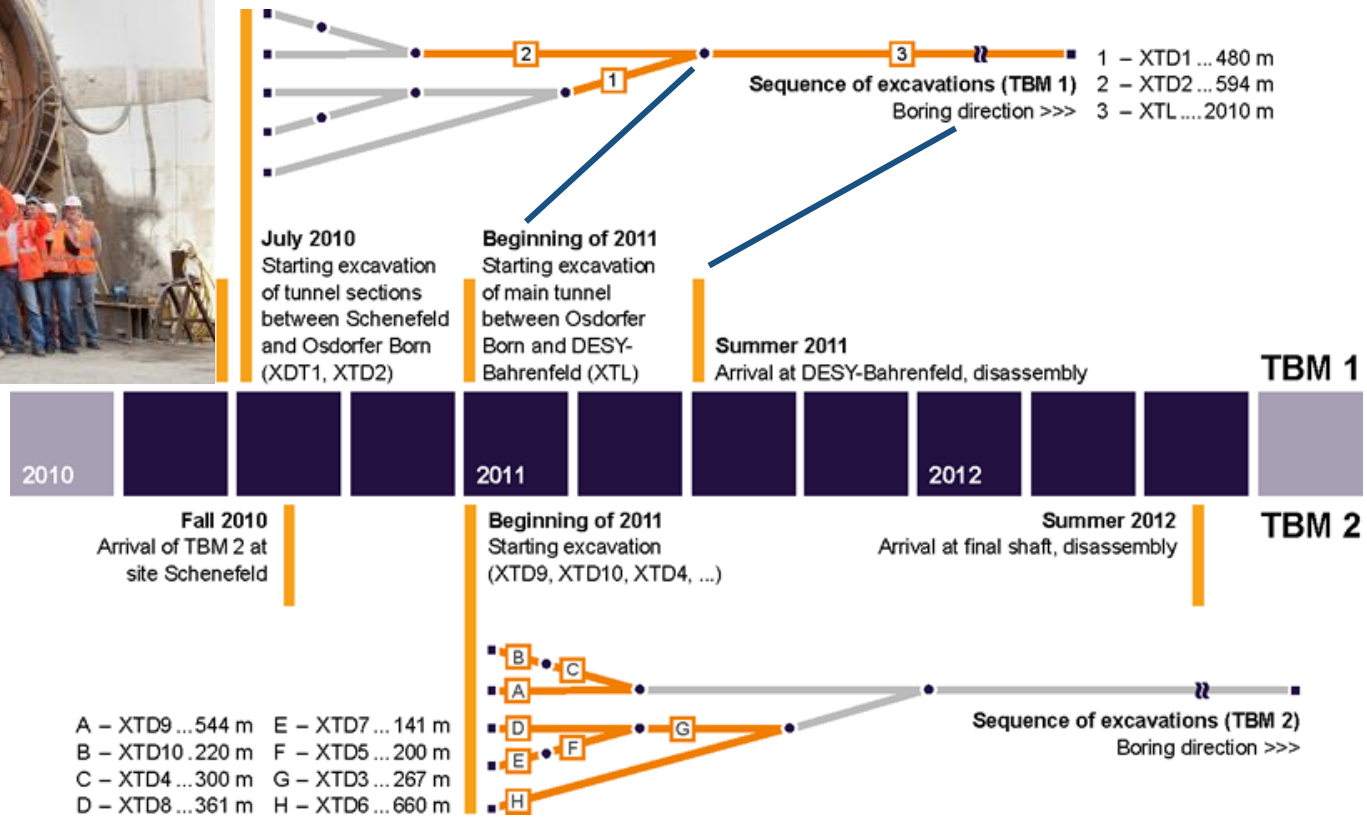
The First Tunnel

DESY

HELMHOLTZ ASSOCIATION

480 m within the First two Months

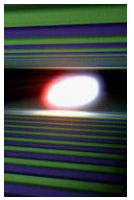
- Starting excavation of main linac tunnel beginning of 2011
- Arrival at DESY Bahrenfeld (injector) in summer 2011



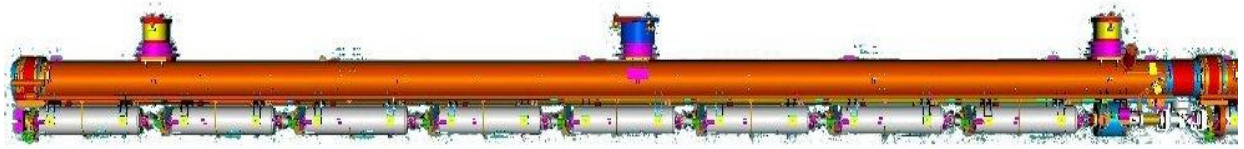
The Injector Building

European XFEL

Accelerator Complex Start-up Version



100 accelerator modules

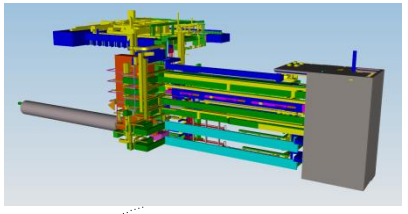


800 accelerating cavities

1.3 GHz / 23.6 MV/m

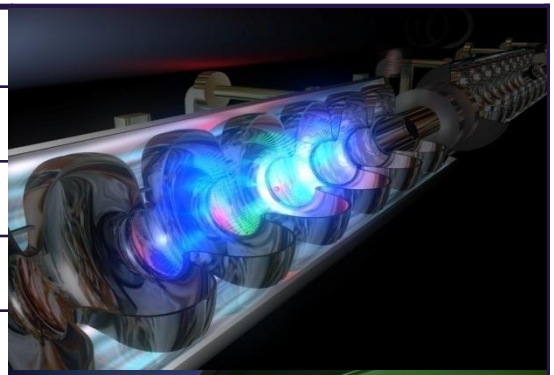
25 RF stations

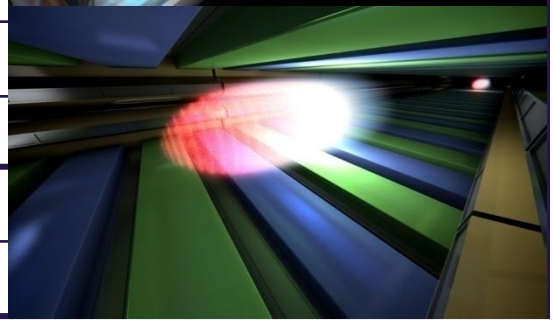
5.2 MW each

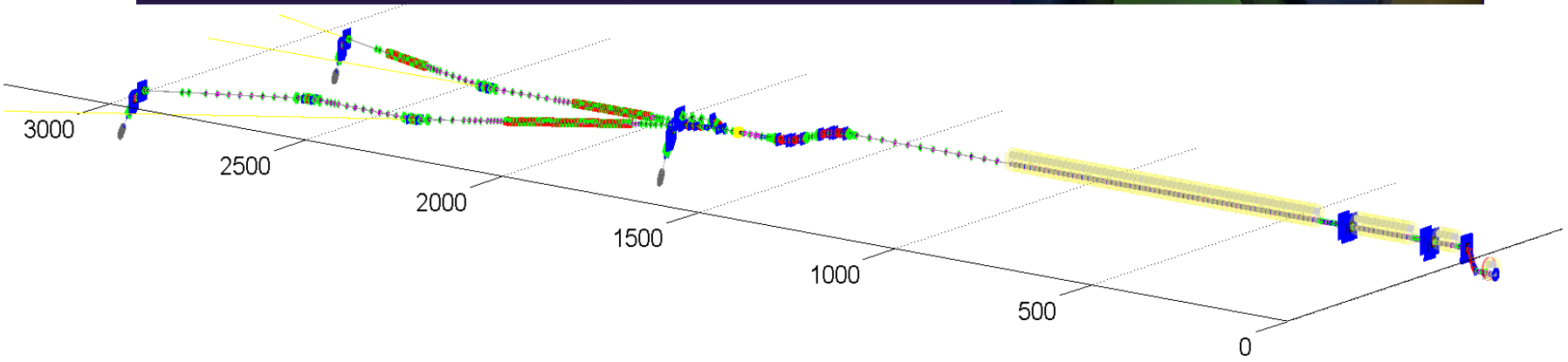


Accelerator Complex Start-up Version

	Baseline
Electron beam energy	17.5 GeV
Bunch charge	1 nC
Peak current	5 kA
Slice emittance	< 1.4 mm mrad
Slice energy spread	1.5 MeV
Shortest SASE wavelength	0.1 nm
Pulse repetition rate	10 Hz
Bunches per pulse	3000

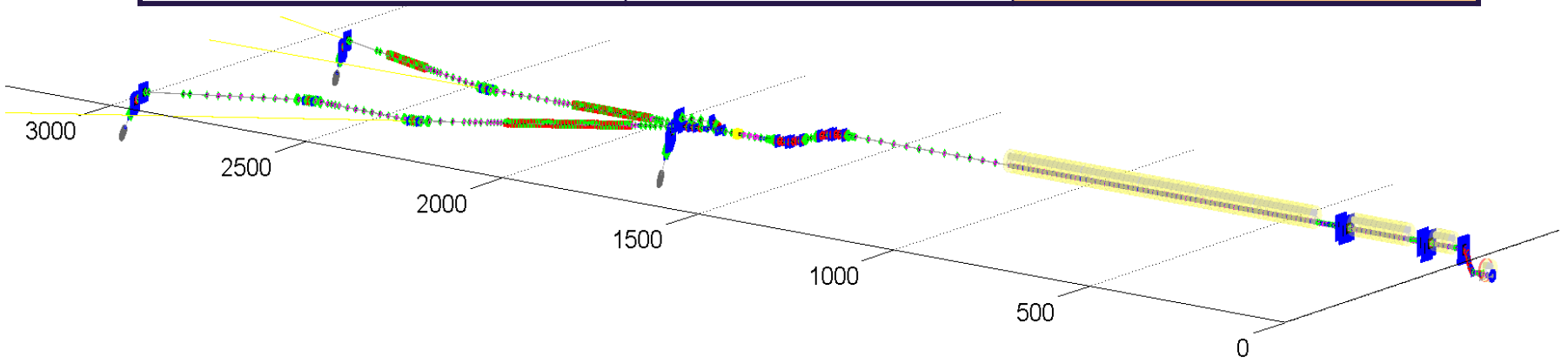






Accelerator Complex with New Parameter Set

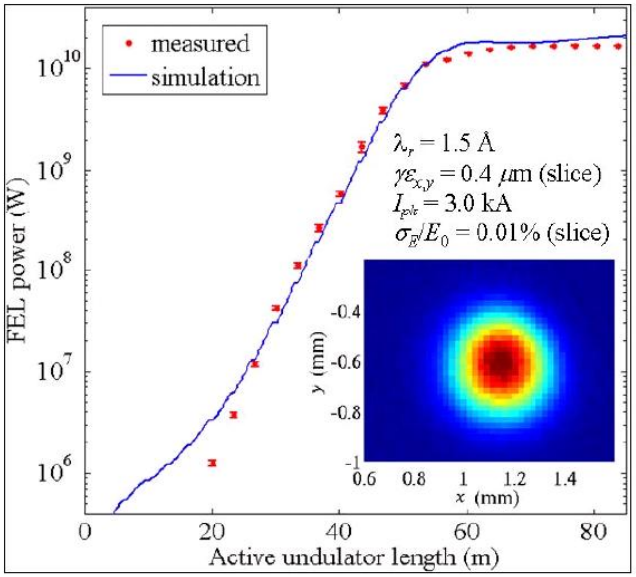
	Baseline	New Parameter Set
Electron beam energy	17.5 GeV	14 GeV
Bunch charge	1 nC	**0.02 - 1 nC**
Peak current	5 kA	2 - 5 kA
Slice emittance	< 1.4 mm mrad	**0.4 - 1.0 mm mrad**
Slice energy spread	1.5 MeV	4 - 2 MeV
Shortest SASE wavelength	0.1 nm	**0.05 nm**
Pulse repetition rate	10 Hz	10 Hz
Bunches per pulse	3000	2700



Results from LCLS

0.25 nC

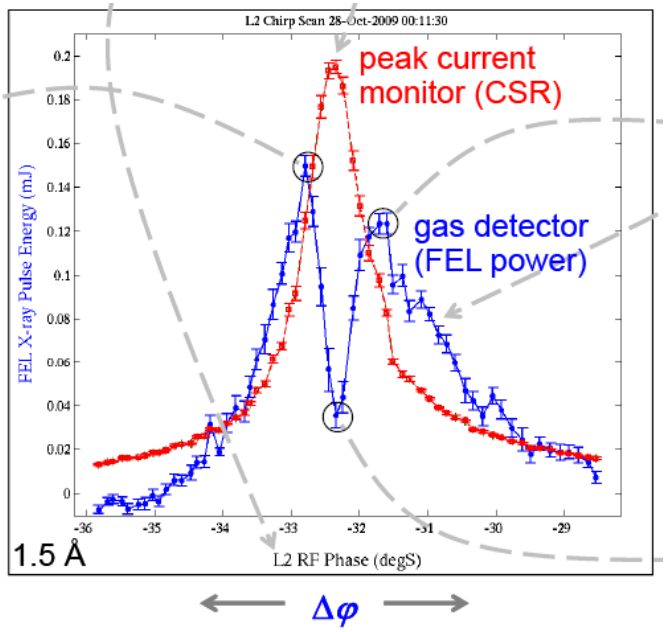
Saturation after 65 m



Courtesy P. Emma, H.D. Nuhn, et al.

20 pC

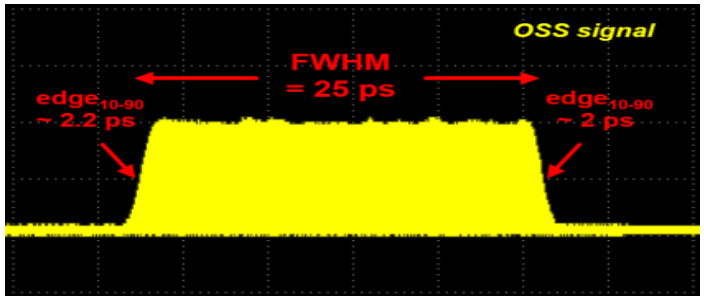
X-ray pulse should be < 10 fs (no measurement possible yet)

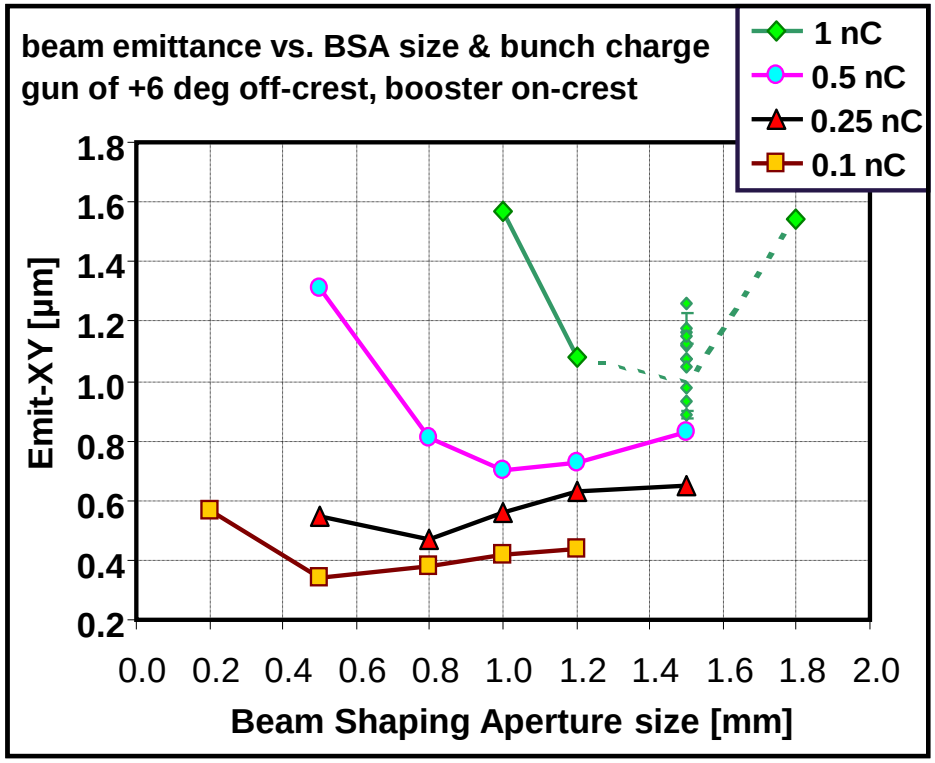


Consequences for the European XFEL

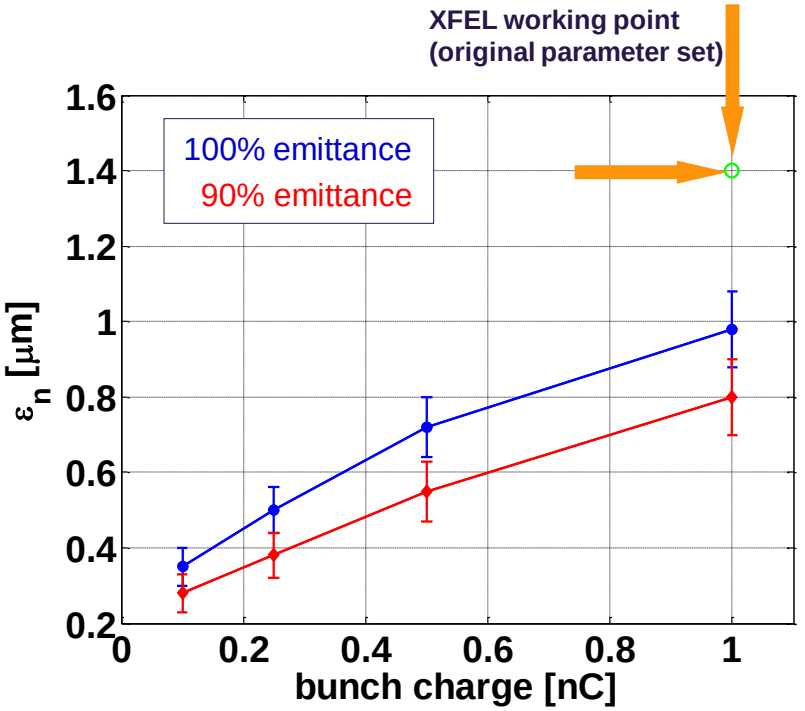
- SASE with electron beam parameters as simulated => safety margins can be reduced
- Operation at low charges with strong compression feasible => include scheme from beginning

Latest DESY PITZ Results on Emittance

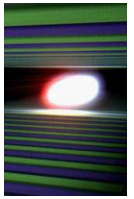




Measured projected emittance versus bunch charge

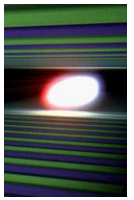


Possible Shortening of the LINAC

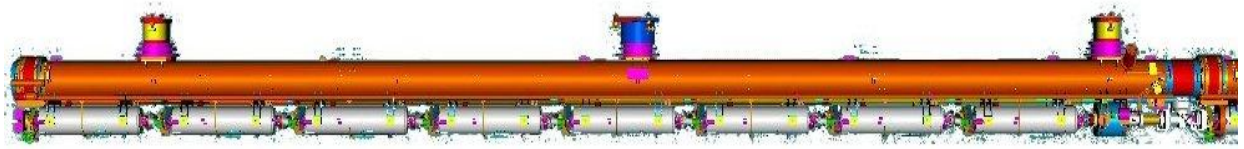


- Improved beam quality **gives possibility to save money** by shortening the linac while keeping the baseline performance.
- Extensive simulations support the new parameter set.
- **BUT:**
  - Reduced safety margin
  - Reduced photon energy reach
  - Makes eventual later conversion to cw more expensive
- Proposal to XFEL Council $\mathbf{E_{final} = 17.5\ GeV \rightarrow 14\ GeV}$
- All other accelerator system still laid out for >17.5 GeV
- Missing modules will be substituted by simple warm beamline
  - approx. 6 additional quadrupoles are required
  - additional 240 m of 40.5 mm beam-pipe

Accelerator Complex with New Parameters



80 accelerator modules

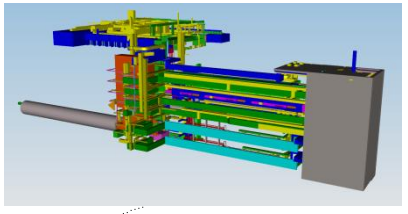


640 accelerating cavities

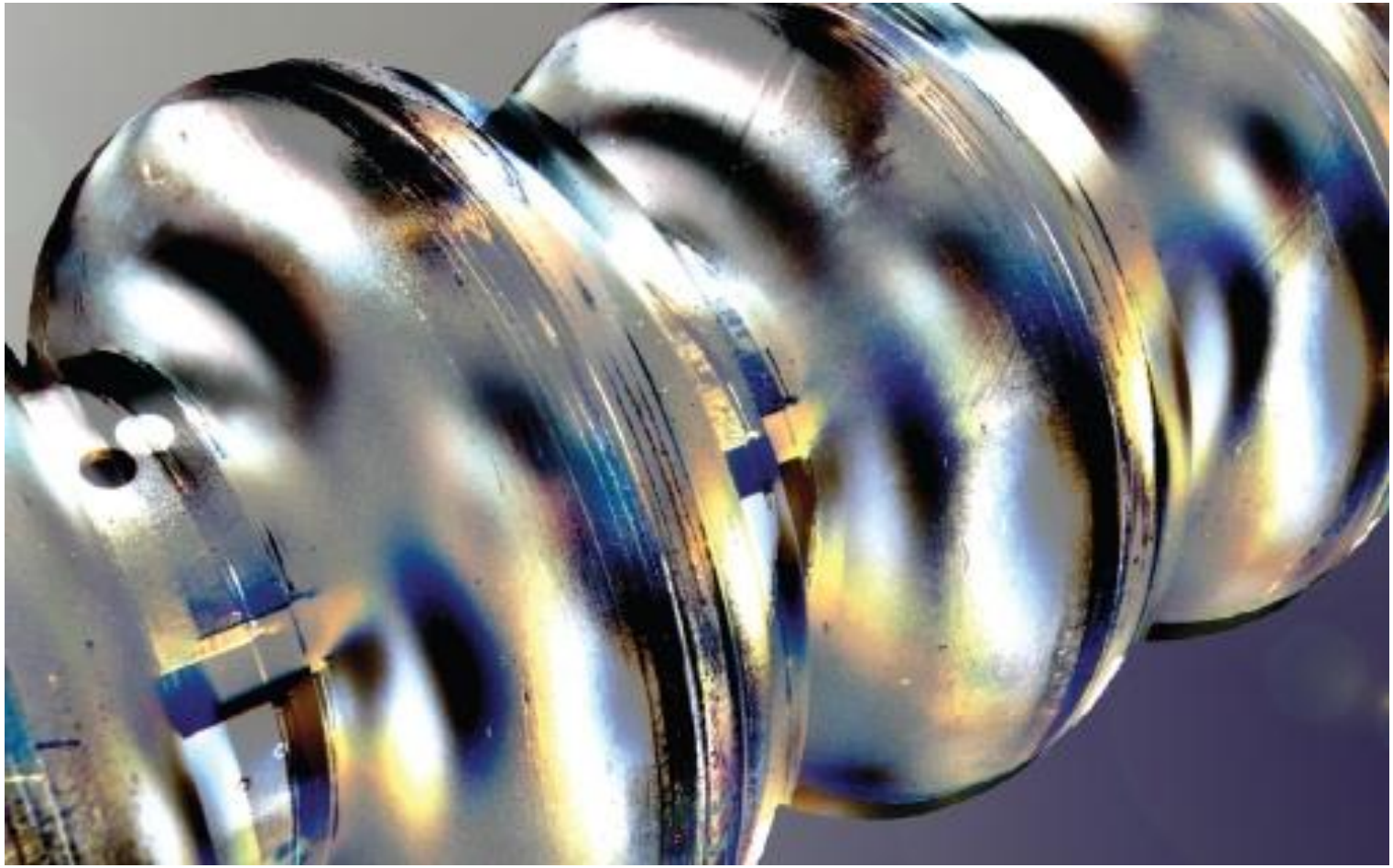
1.3 GHz / 24.3 MV/m

20 RF stations

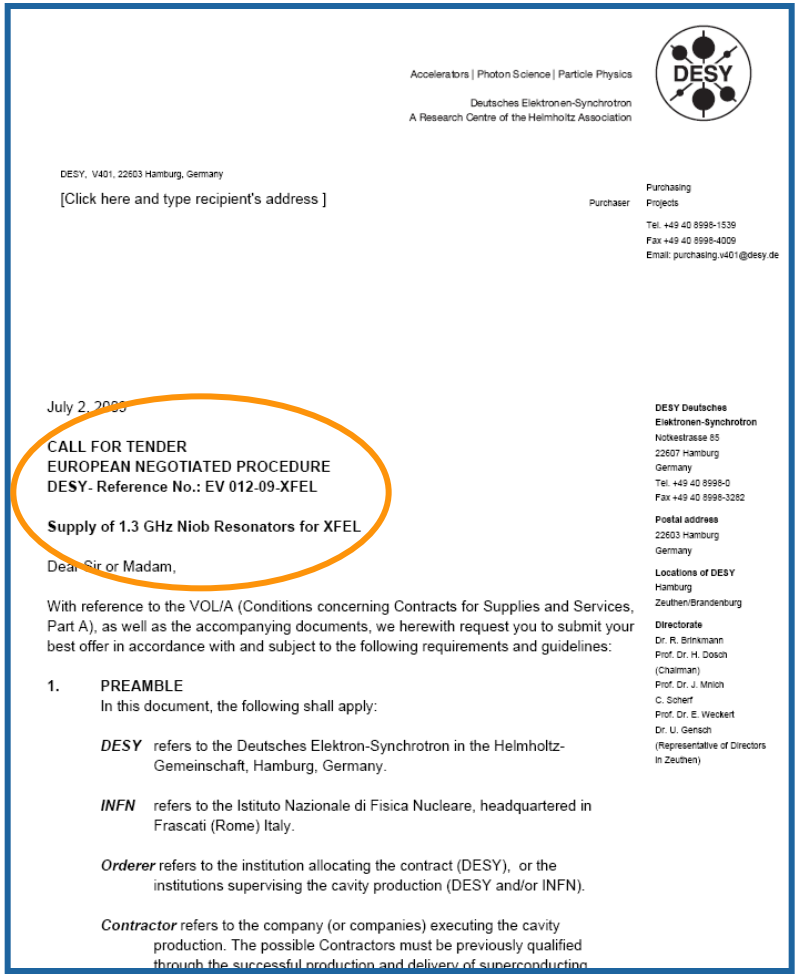
5.2 MW each



Cavities



Cavities – Call for Tender (CFT) in 2009



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

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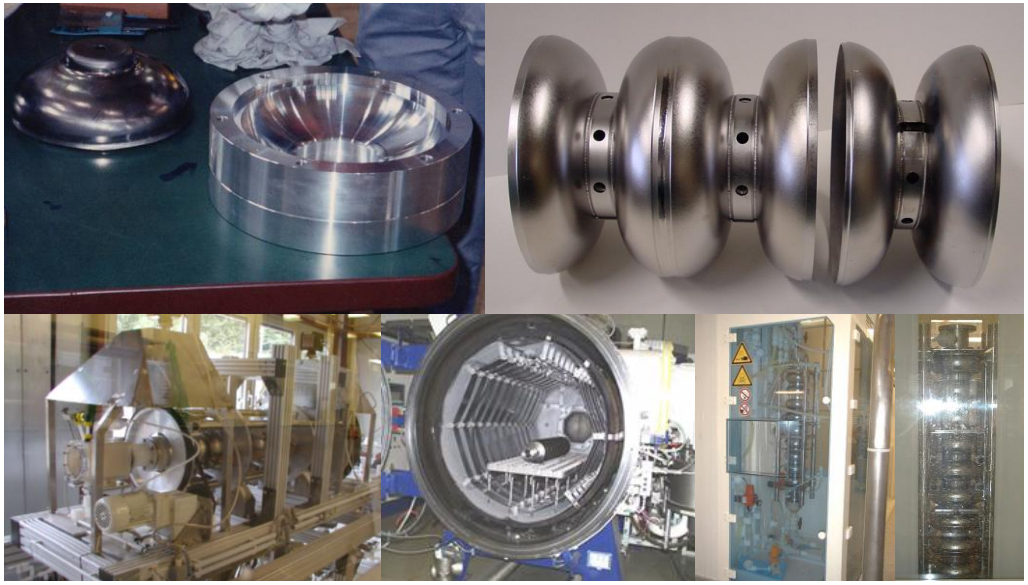
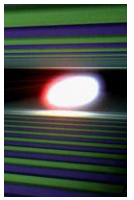
Locations of DESY
Hamburg
Zeuthen/Brandenburg

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)

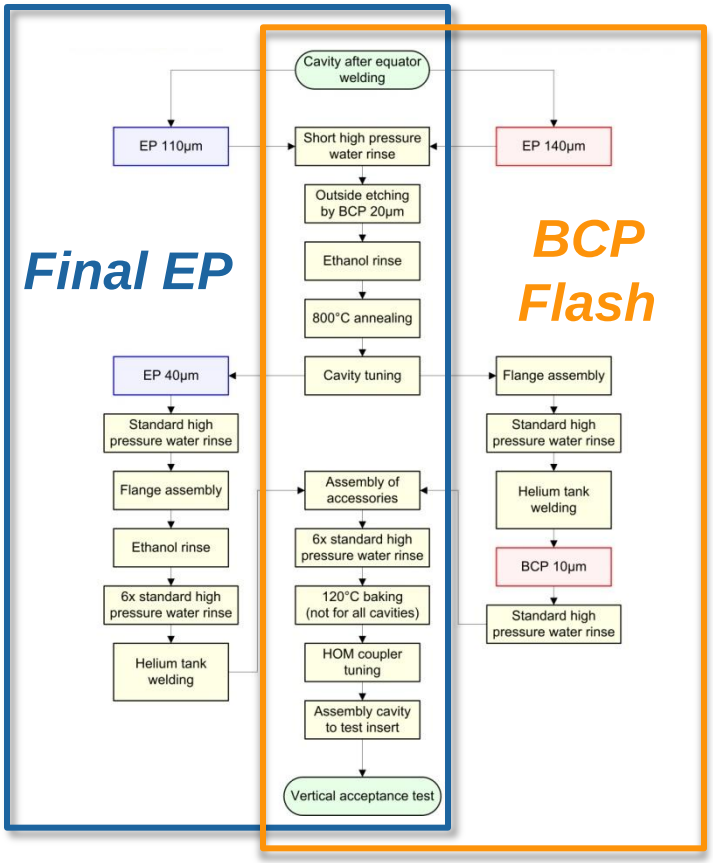


- After the Production Readiness Review the Cavity **Call for Tender was published** on July 2nd, 2009.
- **Production and preparation** in industry.
- Contracts to be allocated by DESY and supervision of cavity production by DESY/INFN.
- **Negotiations with vendors in two iterations.**
- Funding politically complicated.

Cavity Surface Treatment – Based on DESY Experience

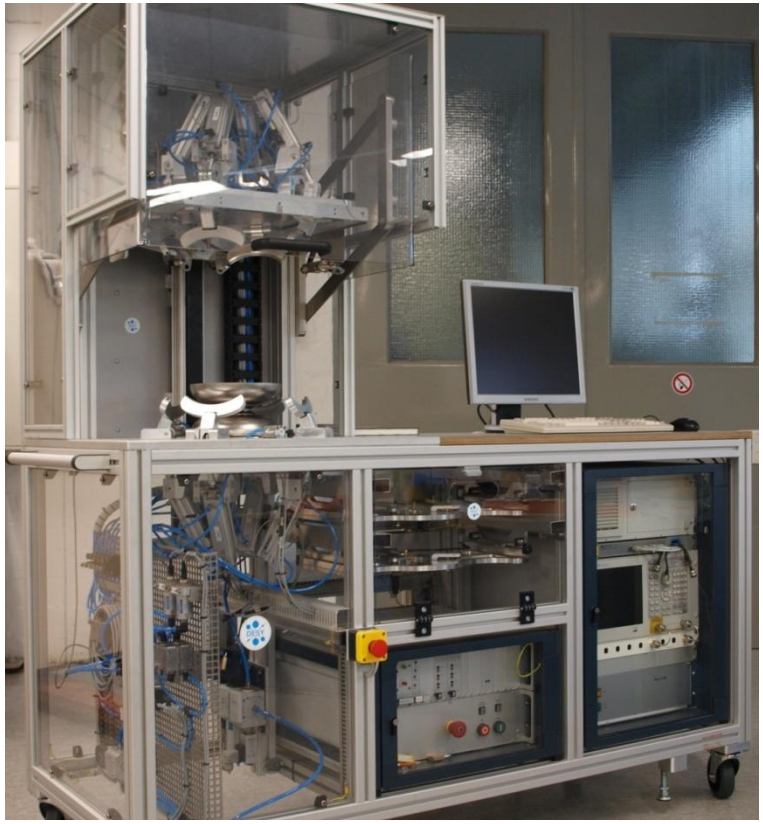


- **Two schemes** for the final surface treatment (***Final EP*** and ***BCP Flash***) were studied with **cavities from two different vendors**.
- The **preparation strategy** to go for a final treatment with the cavity already welded into the He-vessel was investigated.



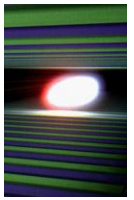
- **Results** are:
  - yield curves for the different schemes
  - yield curves for the different vendors
  - a preparation strategy allowing two different final treatments
- Some **tooling** will come from DESY
- **DESY procedures and experience** described very much in detail in the CFT
- Specification will be **made available** to the SRF community around end of 2010.

RF Measurement and Field Flatness Tuning using DESY-provided Tools



- Both machines ready to be used at the companies (CE certified).
- Machines can be operated by Non-RF-Experts.
- **Considerably shorter measurement / tuning time.**
- Automation and documentation guaranteed.

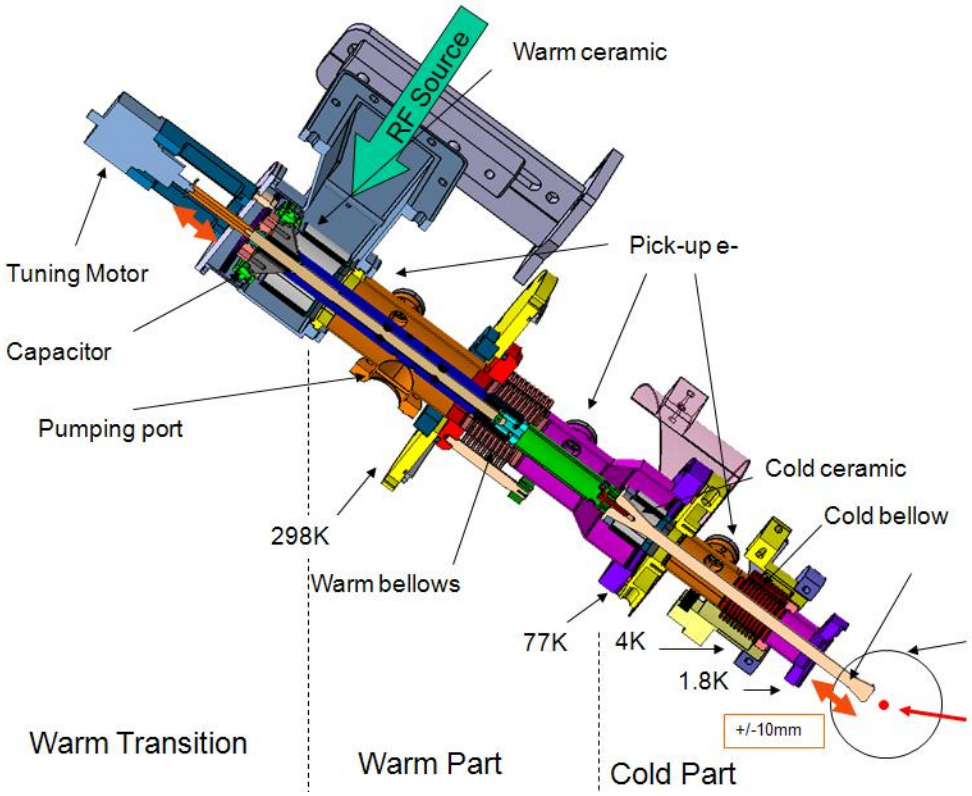
Cavities – The Contracts



- **Research Instruments and E. Zanon** were contracted **to produce each**
  - 4+4 **pre-series cavities**
  - **280 XFEL type series cavities**
  - **12 HiGrade cavities**, first used for quality assurance, later available for further investigations & treatments (high gradient R&D towards ILC)
  - **Nb / NbTi to be supplied by DESY**
  - Production precisely following the specifications which also include the exact definition of infrastructure to be used
  - Final treatment after bulk electro-polishing (EP): EP for RI / flash BCP for Z
  - **No performance guaranty by the vendors**, i.e. the risk of unexpected low gradient or field emission is with DESY (responsibility for re-treatment); goal: average usable XFEL gradient 24.3 MV/m
  - **Additional 80 cavities** are ordered as an option to be placed after the evaluation of the successful start of the series production
  - **First series cavities beginning of 2012**; all cavities to be delivered within two years; He-vessels for RI cavities to be supplied by DESY
  - Both contracts have a volume of almost 25 M€ each

Cavity - Kick-off Meetings

XFEL RF Power Coupler – LAL Orsay Contribution



- Contract for the **production of 640 couplers** recently placed at a consortium of **THALES & Research Instruments.** Kick-off Meeting on Sep.13, 2010.

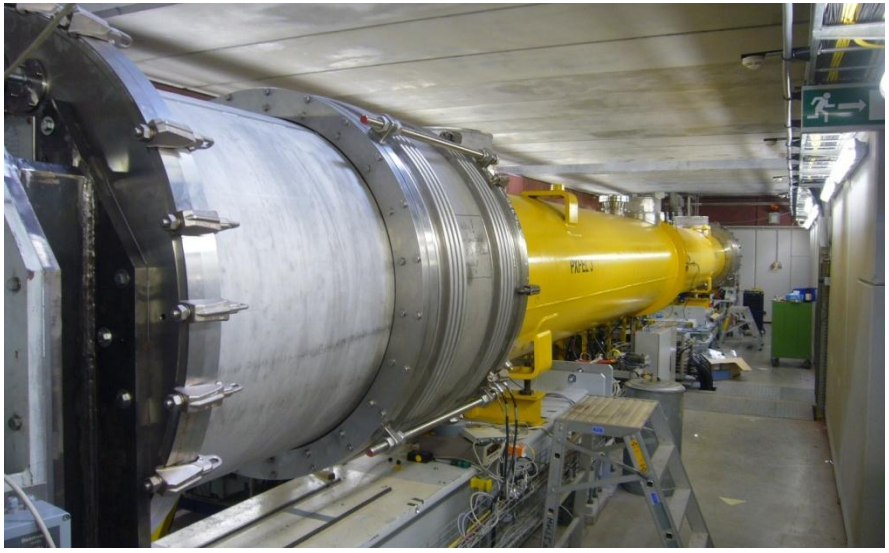
- **LAL Orsay** has taken over the responsibility for the XFEL RF power **coupler production**.
- **Conditioning** of the couplers will take place at LAL Orsay.
- The **coupler interlock** system was developed and will be **contributed by DESY.**

XFEL RF Power Coupler – Conditioning at LAL

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

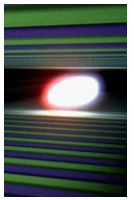
- Conditioning rate of **8 couplers per week** with max. 5 MW RF power.
- Either pairs (4 x 2 couplers) or units of 4 couplers (under study).
- Schedule integrated in overall project schedule.
- Direct delivery to assembly site at CE Saclay.

PXFEL – Three Modules from Different Vendors



- Three XFEL prototype modules were built and tested.
- Assembly procedures improved during assembly training with new teams.

PXFEL – Modules from Different Vendors



- PXFEL1 is a great module above 30 MV/m; cryostat contributed by IHEP Beijing.
- After string / module installation the **gradient reduction is only 5%.**
- Now operated at FLASH with an average gradient of **30 MV/m using the XFEL waveguide distribution.**

- Module PXFEL3 is **currently under test**.
- Mechanically ok
- Cryogenic losses & gradients are next.
- **Improved current leads** for sc quadrupole magnets are used.

- PXFEL2: av.gradient 29.6 MV/m
- **BUT:** 3rd cavity dropped from 27 down to 16 MV/m and neighboring cavities show field emission.
- Looks like an assembly problem but no hint in the reports**. Module was used for string & module assembly training.**

- PXFEL1 — Institute of High Energy Physics, Chinese Academy of Sciences
- PXFEL2 — duro felguera, s.a.
- PXFEL3 — THALES

PXFEL – Call For Tender

- All PXFEL cryostats seem to be acceptable. We have seen a **successful technology transfer.**
- Together with E. Zanon who has produced all the previous cryostats we now have **four experienced vendors**.
- DESY is going to publish the **Call for Tender in the next weeks**.

E. ZANON SINCE 1919

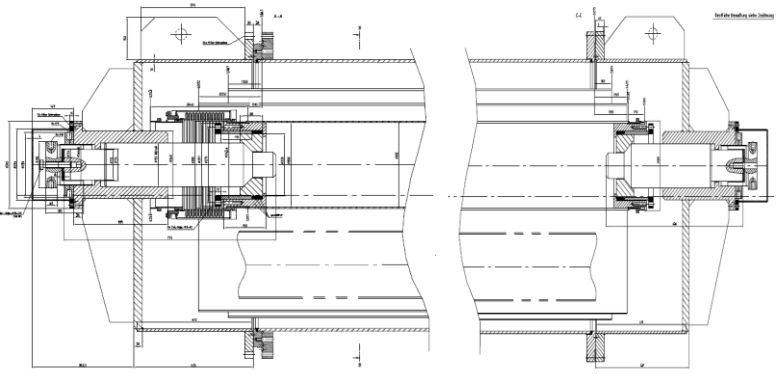
Institute of High Energy Physics
Chinese Academy of Sciences

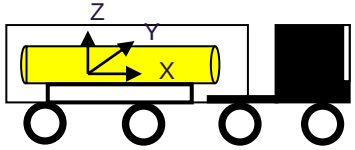
duro felguera, s.a.

THALES

PXFEL2 – Travelled from DESY to Saclay to DESY to Saclay … as an Excersise …

… and a Test for the Transportation Tools

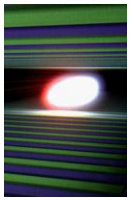


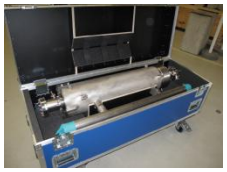


Accelerometers
Permanent leak check
etc.

- **Feed-cap side**
- **End-cap side**

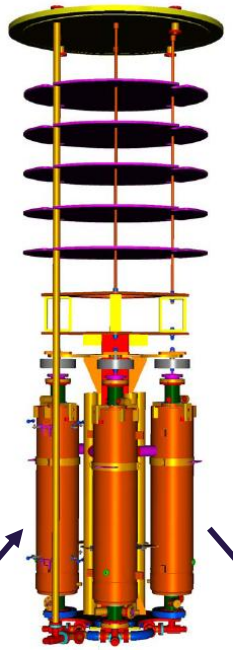
Transport Solution for XFEL Cavities





RI Germany

Z Italy



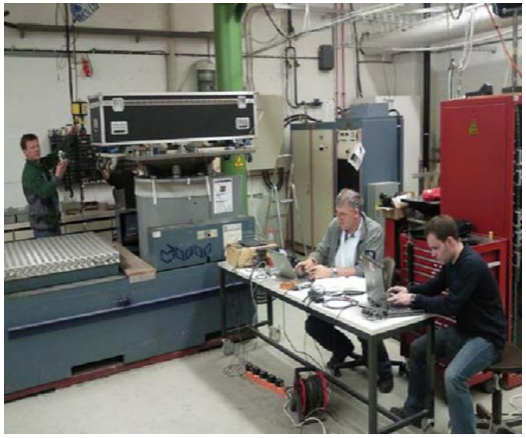
DESY Germany

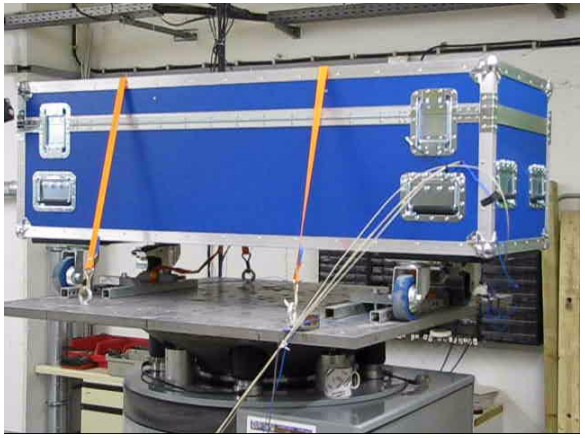
IRFU /CEA France

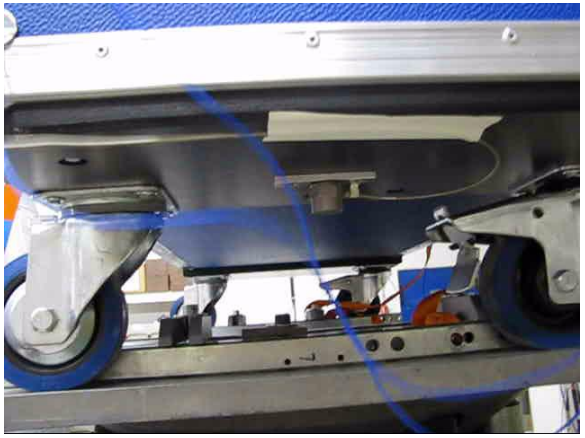
- **DESY takes care of installation / dismounting of cavities into / from test insert**
- **Transport to CEA in transport boxes as well**

European XFEL

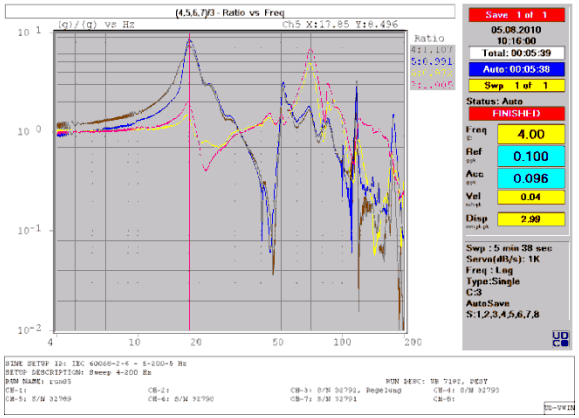
Transport Simulation

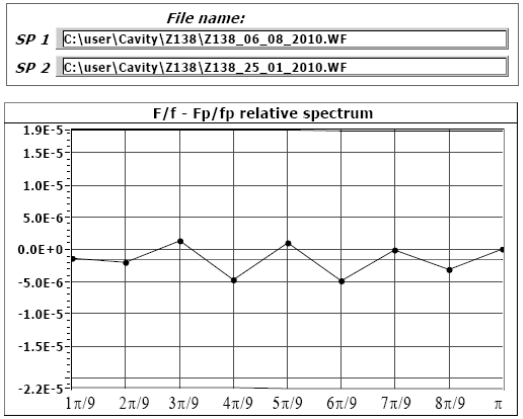


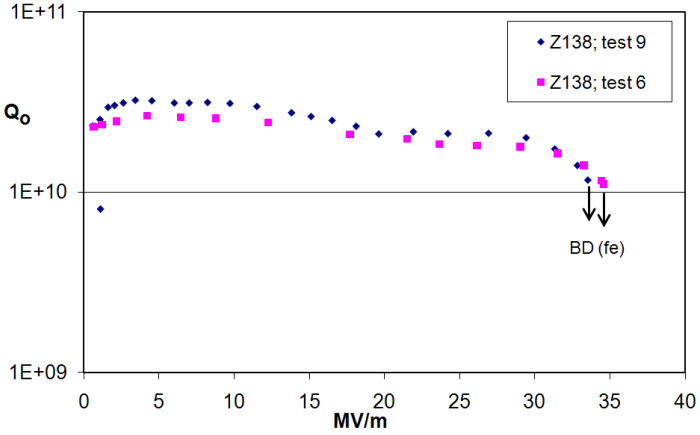




- Sweep (0.1 g), Transport simulation (up to 2 g) 1200 km with Shocks applied up to 6 g
- Final test done without external dampers, only internal foam elements.







- Eigen frequencies
- Field flatness
- Cavity gradient

DESY HELMHOLTZ ASSOCIATION

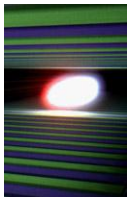
Cavity String & Module Assembly

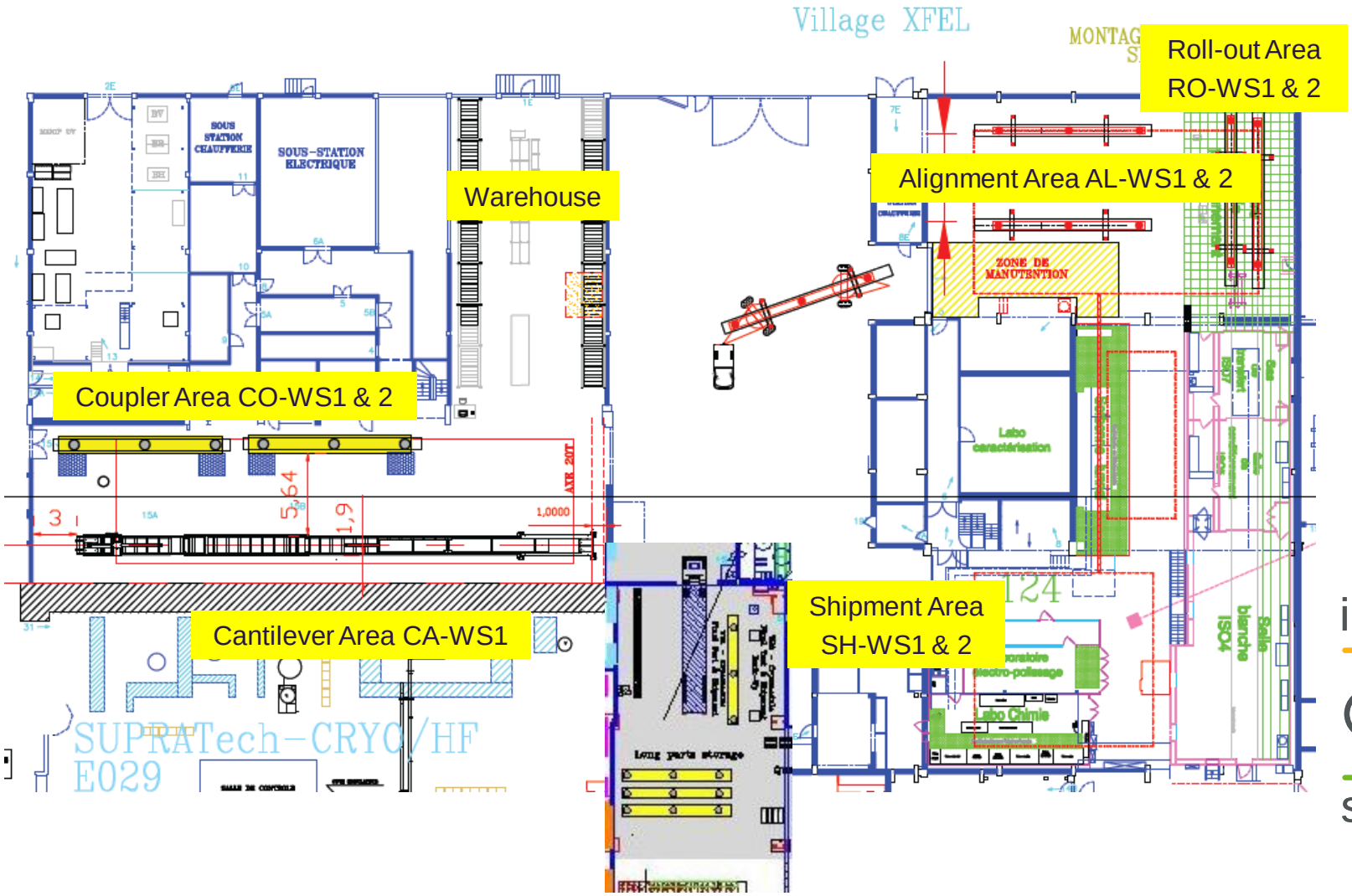
- Using experience gained at DESY and results of industrial studies, the assembly facility for all XFEL modules will be set up at the CEA-Saclay site.

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

European XFEL

Module Assembly - Workstations





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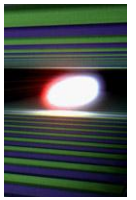
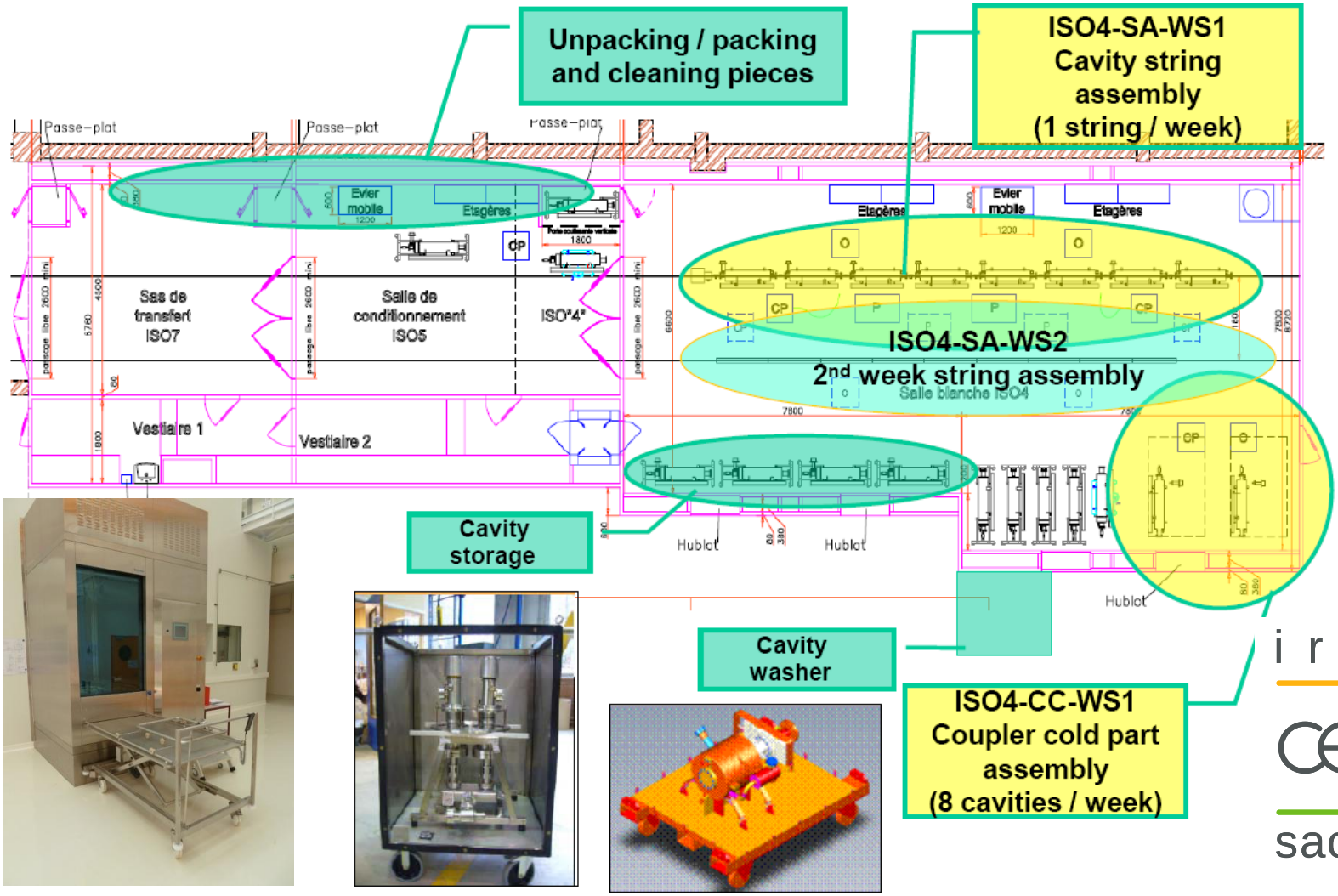
String Assembly - Workstations





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- All cavities with He tank, the coupler cold parts and the quadrupole-BPM units will be cleaned and dried externally before entering ISO4 area

European XFEL

Infrastructure for Cavity String Assembly

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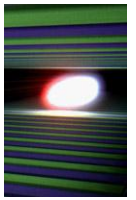
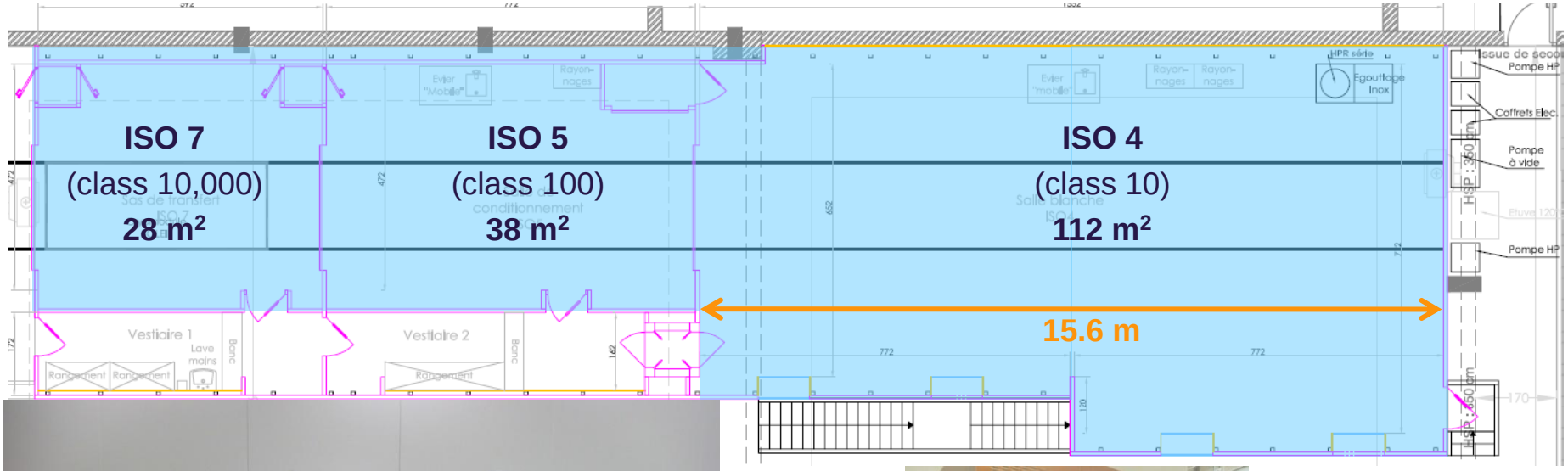
Infrastructure for Cavity String Assembly





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Module Assembly Halls at CE Saclay

- Three Assembly Halls and Services (offices, dressing rooms, warehouse, central courtyard, etc…) were under rehabilitation:

- **Hall n° 1 is ready**
  - **Roll-out Area (RO-WS1, RO-WS2)**
  - **Alignment Area (AL-WS1, AL-WS2)**

- **Hall n° 2 is ready**
  - **Cantilever Area (CA-WS1)**
  - **Coupler Area (CO-WS1, CO-WS2)**
  - **+ offices and warehouse**

- **Hall n° 3 is ready**
  - **Shipment Area (SH-WS1, SH-WS2)**

Assembly Hall and Services ready: April 2010
Central courtyard re-surfaced in June 2010.

Refurbished DESY Clean Room

- State-of-the-art
- Now used for assembly training
- Later available for repair work

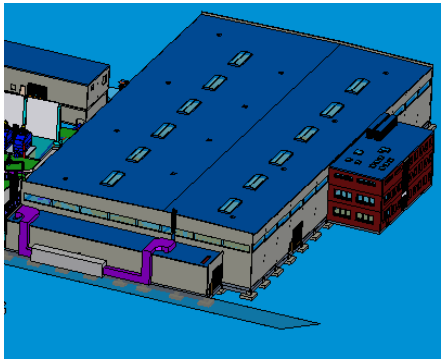
- Increased ISO4 assembly area
- Chemistry and ultra sound infrastructure now in ISO6/5 instead of ISO7/6
- New rotational clean room airlock

- Two independent air systems
- Improved energy balance

European XFEL

Civil Construction Accelerator Module Test Facility

- AMTF hall available since 5/2010
- AMTF Controls Building 10/2010
- Technical infrastructure (mains, water etc.) 10/2010
- Concrete shielding & accessories end of 2010



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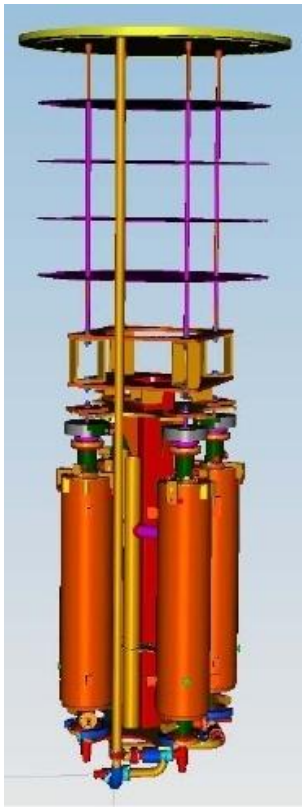
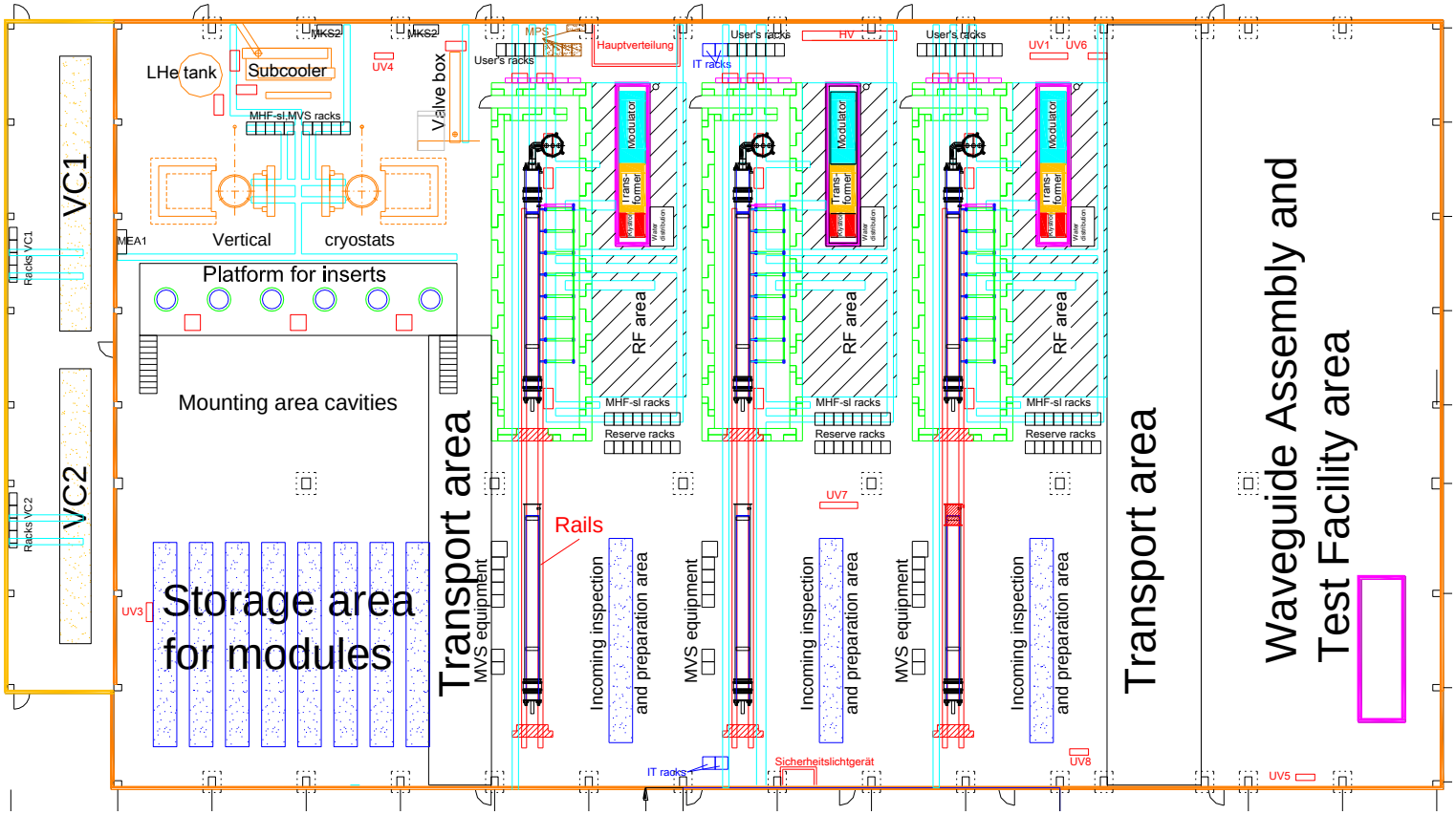
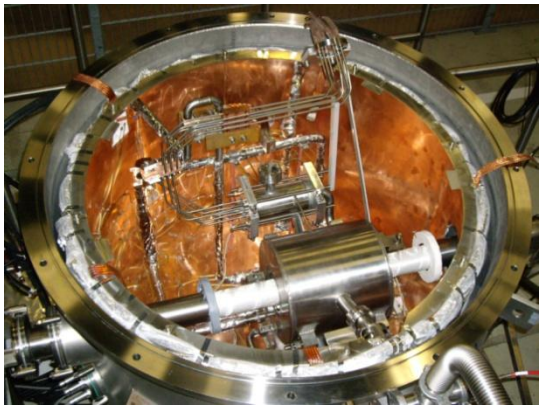
Accelerator Module Test Facility (AMTF) Including Single Cavity Tests





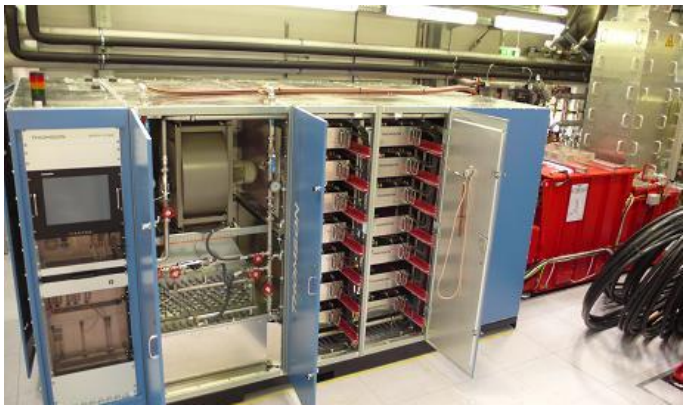
- **Includes cavity / module & waveguide assembly / test**
- **Commissioning**
  - **cavity tests late fall 2011**
  - **module tests end 2011**

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

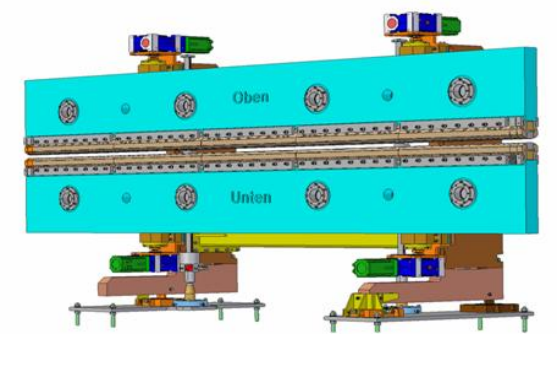


- The first **cold magnet** in the test cryostat.

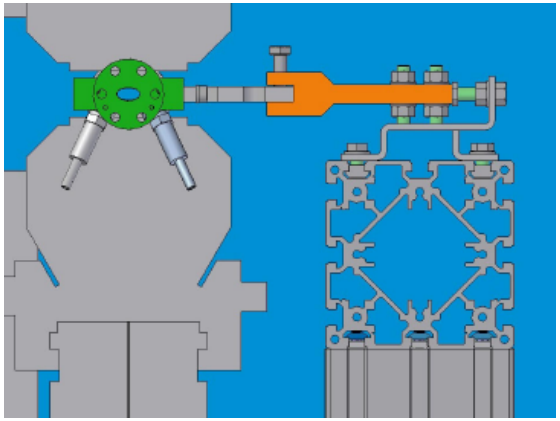
- The **3.9 GHz** FLASH acc-elerator module as prototype.



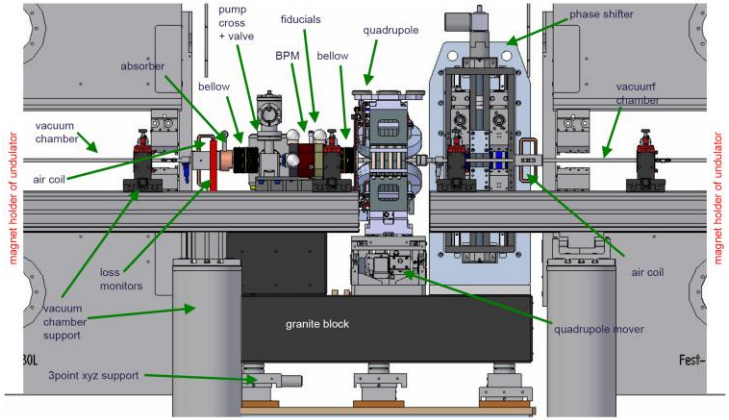
- **RF system** R&D at DESY.



- Approx. **100 undulators** with 585 m total length.

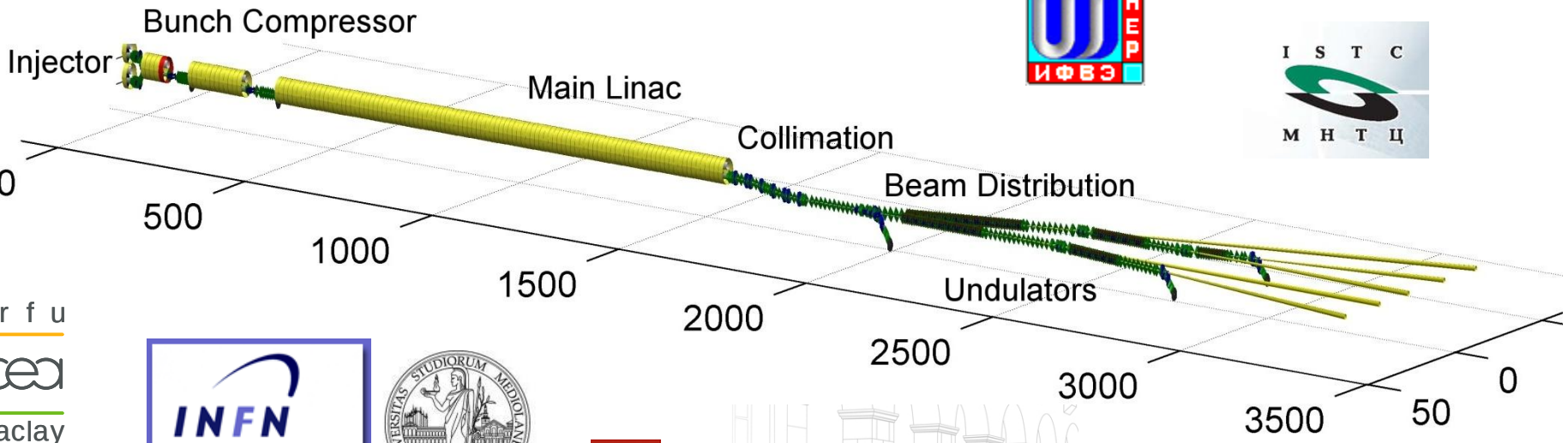


- Undulator beam pipe extr. Al 15 mm x 8.8 mm ellipsoid



- Sophisticated **intersections** incl. Quad / Phase Shifter / BPM

Many Contributions to the Accelerator Complex



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INFN
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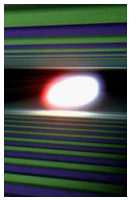
PAUL SCHERRER INSTITUT
PSI

Stockholm University

Institute of High Energy Physics
Chinese Academy of Sciences

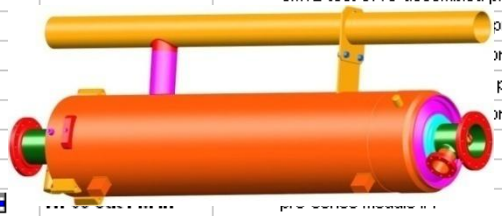
European XFEL

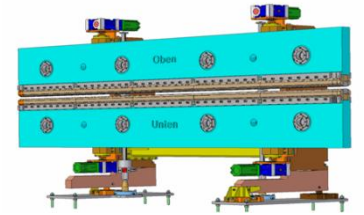
With One Common Goal:

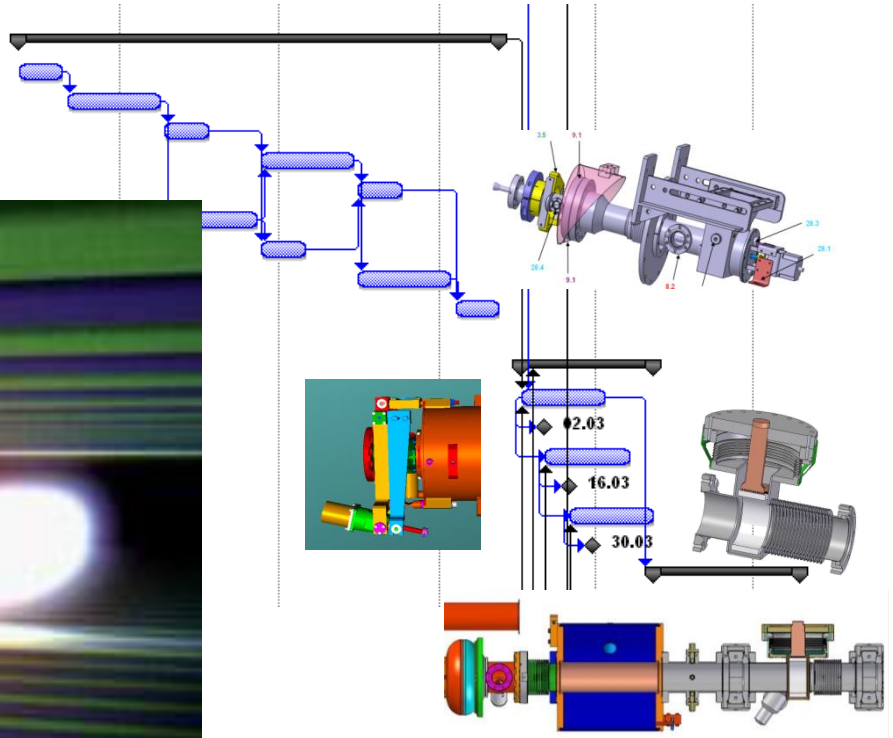


Gantt Chart

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			prototype m	
41			rototype #2	
42			prototype m	
43			rototype #2	
44				
45				
46				
47		WP09 out WP03 in	first pre-series string ready	
48		WP03 out PM in	pre-series module #2	
49		WP09 out WP03 in	second pre-series string ready	
50		WP03 out PM in	pre-series module #3	
51		WP09 out WP03 in	third pre-series string ready	
52			start CMTB module testing	
56				







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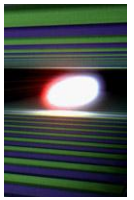

The end