

## **IWLC2010** International Workshop on Linear Colliders 2010

ECFA-CLIC-ILC Joint Meeting: Monday 18 October - Friday 22 October 2010

Venue: CERN and CIG (International Conference Centre Geneva, Switzerland)

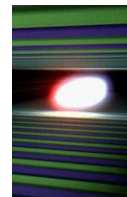
# **Experience from the European XFEL**

**Some slides from the Linac 2010 talk...**

**Hans Weise / DESY**

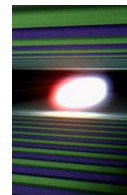


# The Cutter Head





# Tunnel and Borer Christening Ceremony



■ Saint Barbara, Patroness  
of the Miners

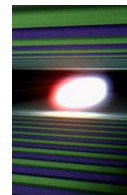




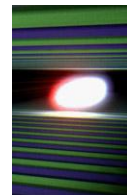
Experience from the European XFEL

European  
**XFEL**

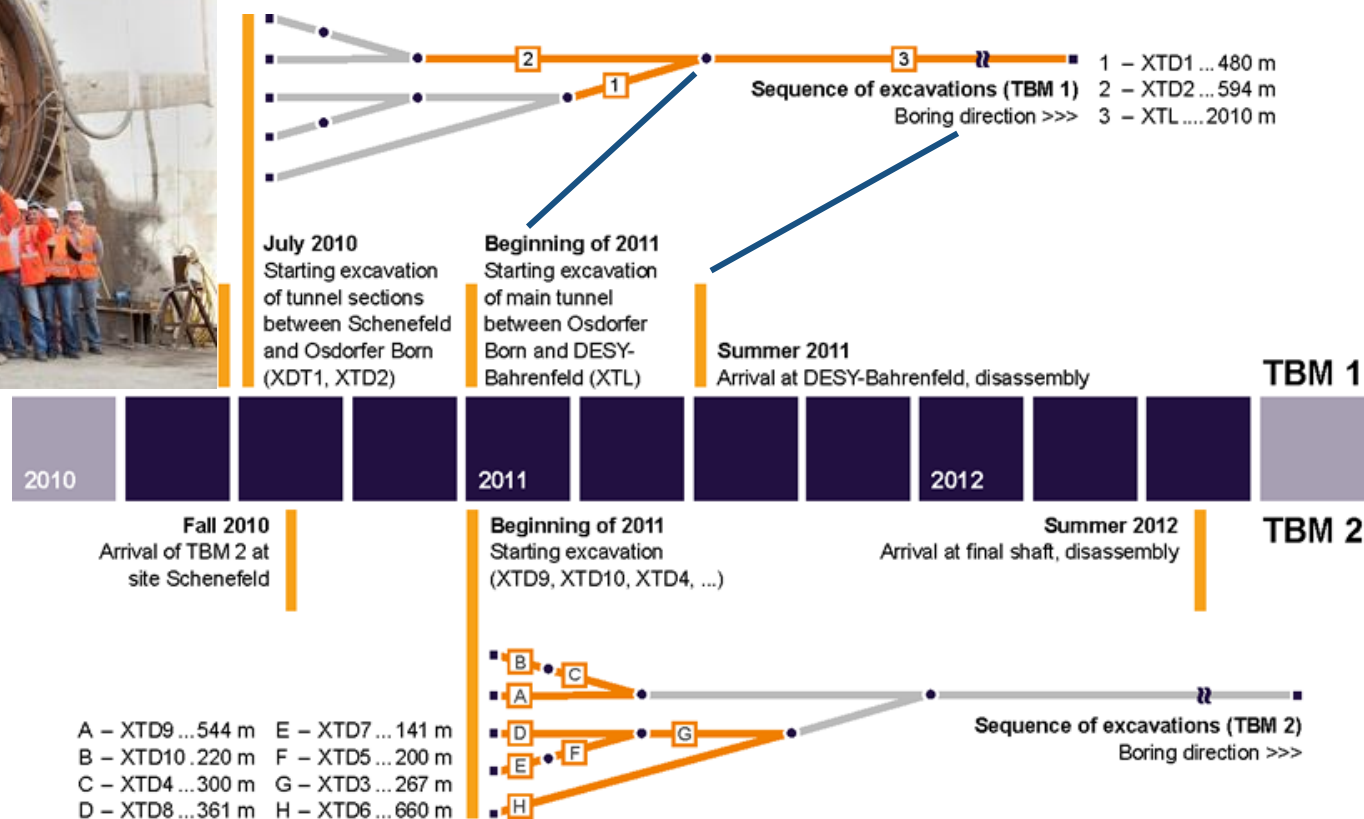
# The First Tunnel



## 480 m within the First two Months

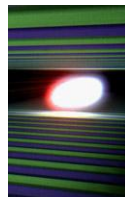


- Starting excavation of main linac tunnel beginning of 2011
- Arrival at DESY Bahrenfeld (injector) in summer 2011



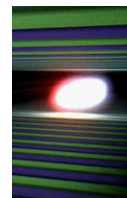


# The Injector Building

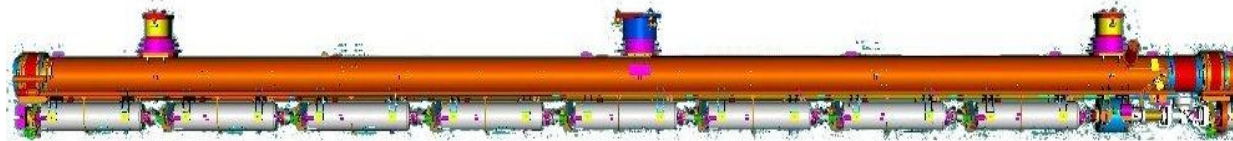




# Accelerator Complex with New Parameters



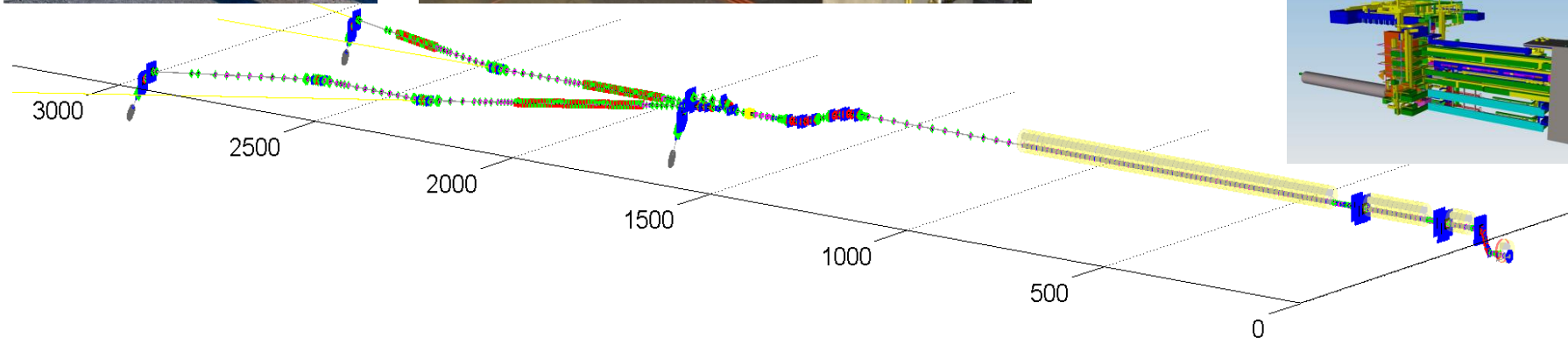
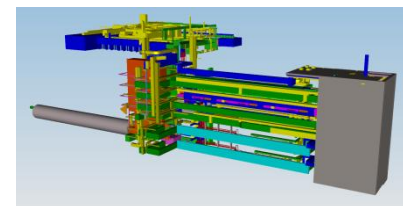
**80** accelerator modules



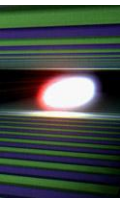
**640** accelerating cavities  
**1.3 GHz / 24.3 MV/m**



**20** RF stations  
**5.2 MW** each

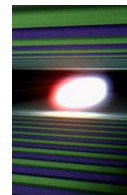


# Cavities





# 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]

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).

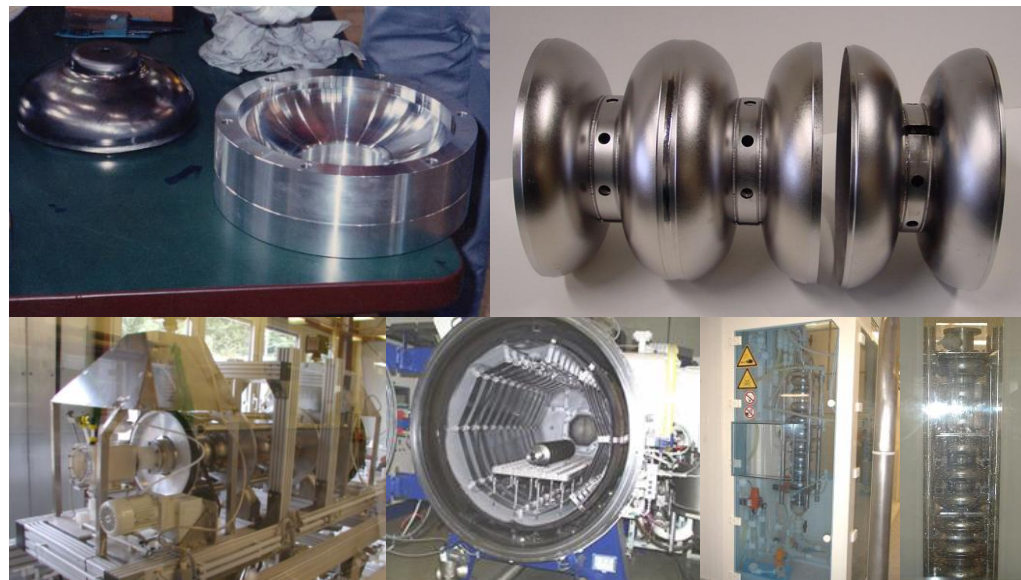
**Contractor** refers to the company (or companies) executing the cavity production. The possible Contractors must be previously qualified through the successful production and delivery of superconducting

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Elektronen-Synchrotron  
Notkestrasse 85  
22607 Hamburg  
Germany  
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22603 Hamburg  
Germany

Locations of DESY  
Hamburg  
Zeuthen/Brandenburg

Directorate  
Dr. R. Brinkmann  
Prof. Dr. H. Dösch  
(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 2<sup>nd</sup>, 2009.

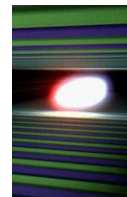
■ **Production and preparation** in industry.

■ Contracts to be allocated by DESY and supervision of cavity production by DESY/INFN.

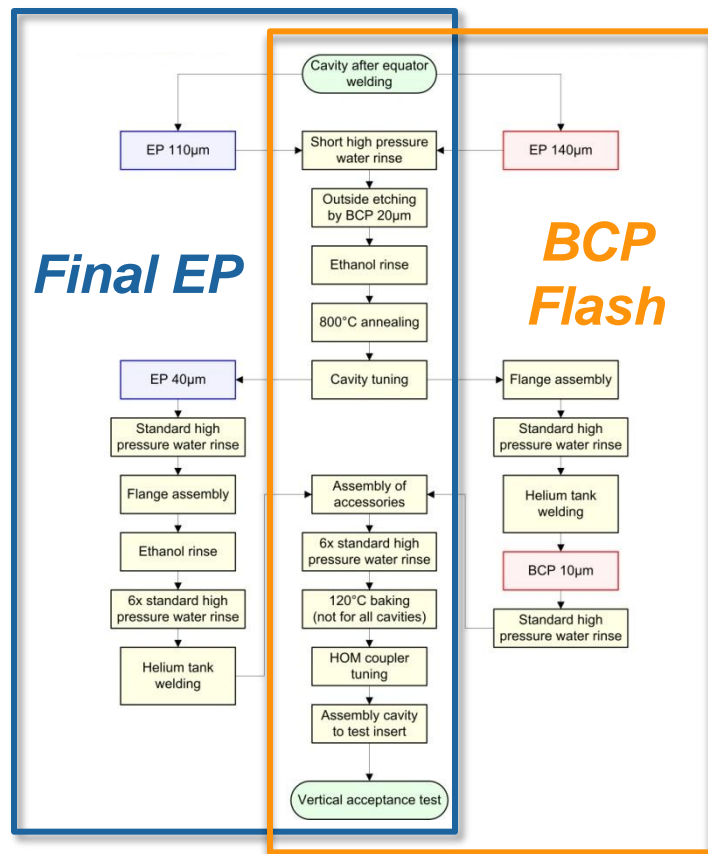
■ **Negotiations with vendors in two iterations.**

■ Funding politically complicated.

# Cavity Surface Treatment – Based on DESY Experience



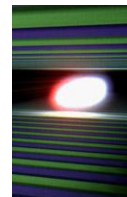
- **Two schemes** for the final surface treatment (*Final EP* and *BCP Flash*) were studied with **cavities from two different vendors**.
- The **preparation strategy** to go for a final treatment with the cavity already welded into the He-vessel was investigated.



- **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.

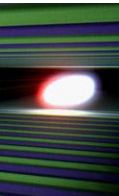


# RF Measurement and Field Flatness Tuning using DESY-provided Tools



- 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.

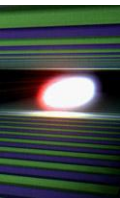
# Cavities – The Contracts



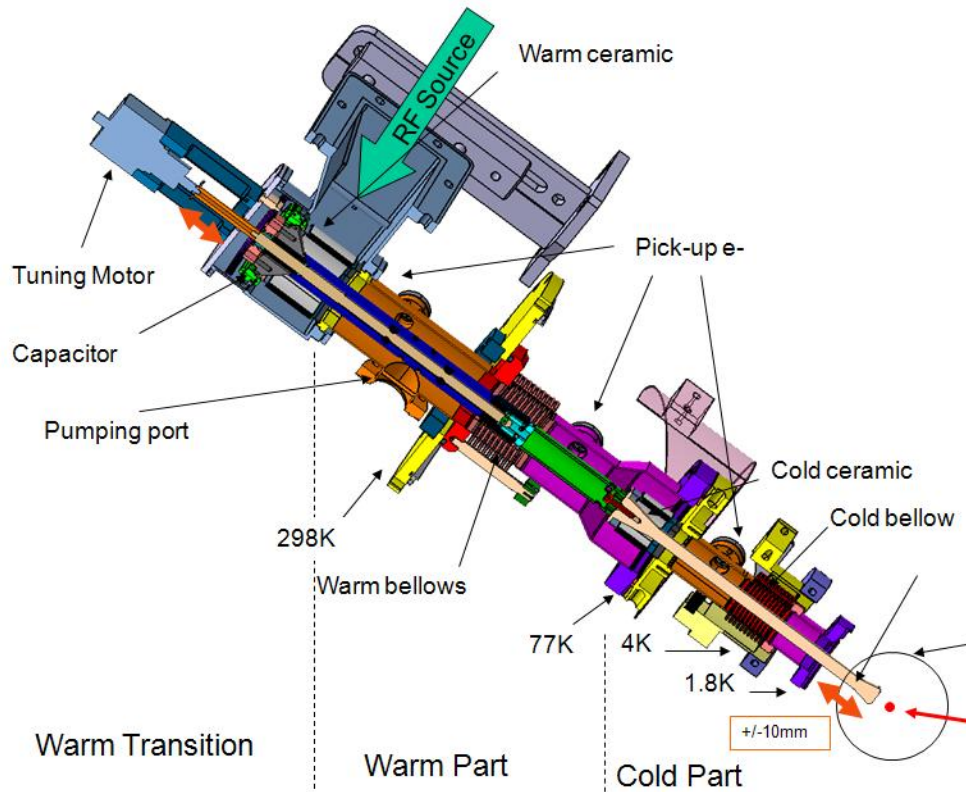
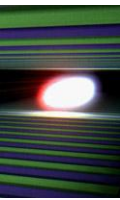
- **Research Instruments and E. Zanon** were contracted to produce each
  - **4+4 pre-series cavities**
  - **280 XFEL type series cavities**
  - **12 HiGrade cavities**, first used for quality assurance, later available for further investigations & treatments (high gradient R&D towards ILC)
  - **Nb / 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.

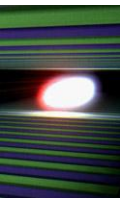
## ■ TTF3 coupler type



- **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**.

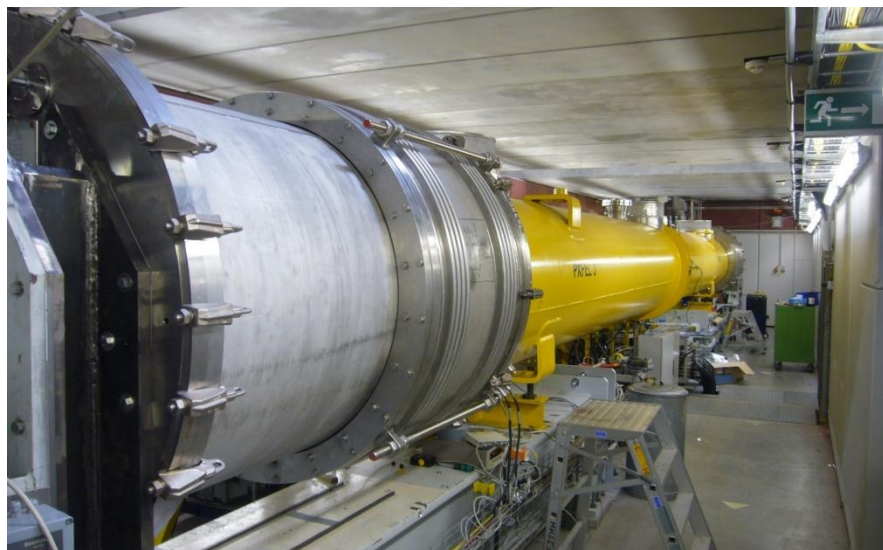
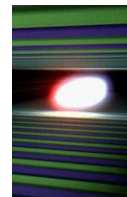


# XFEL RF Power Coupler – Conditioning at LAL



- 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.

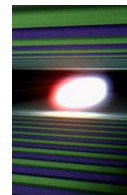
# PXFEL – Three Modules from Different Vendors



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



# PXFEL – Modules from Different Vendors



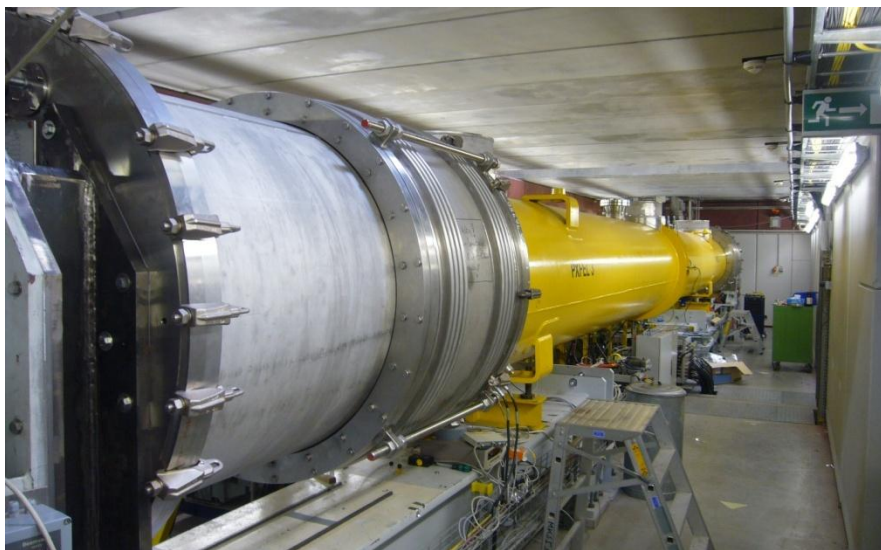
- PXFEL1 is a great module above 30 MV/m; cryostat contributed by IHEP Beijing.
- After string / module installation the **gradient reduction is only 5%.**
- Now operated at FLASH with an average gradient of **30 MV/m using the XFEL waveguide distribution.**



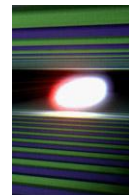
■ PXFEL1



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# PXFEL – Modules from Different Vendors



■ PXFEL1 is a great module above 30 MV/m; cryostat contributed by IHEP Beijing.

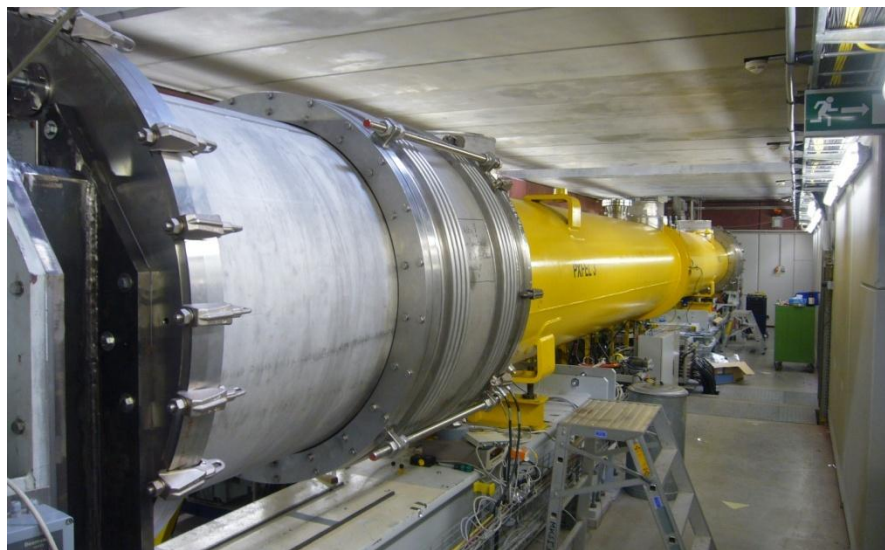
■ After string / module installation the **gradient reduction is only 5%.**

■ Now operated at FLASH with an average gradient of **30 MV/m using the XFEL waveguide distribution.**

■ PXFEL2: av.gradient 29.6 MV/m

■ **BUT:** 3<sup>rd</sup> 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



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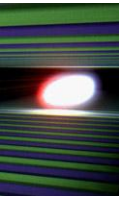
■ PXFEL2



duro  
felguera, s.a.



# 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:** 3<sup>rd</sup> 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



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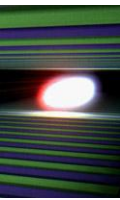
- PXFEL2



- 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 days**.



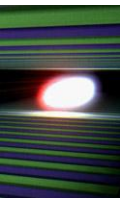
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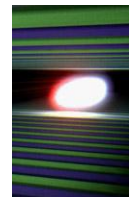
THALES



# PXFEL2 – Travelled from DESY to Saclay to DESY to Saclay ... as an Excercise ...



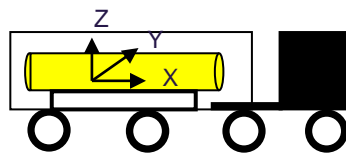
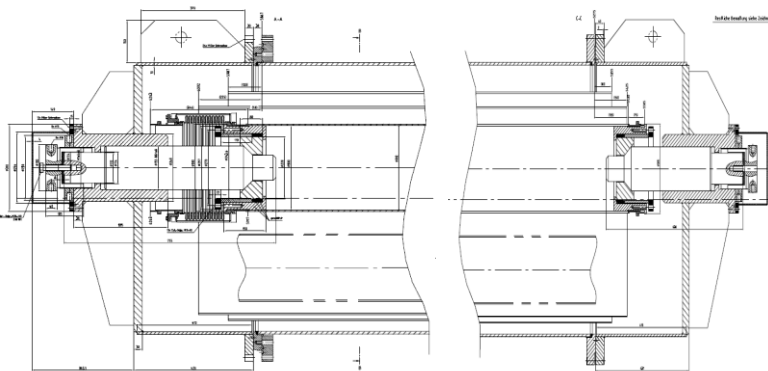
# ... and a Test for the Transportation Tools



irfu

cea

saclay



Accelerometers  
Permanent leak check  
etc.

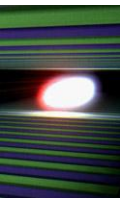
■ Feed-cap side

■ End-cap side





# Transport Solution for XFEL Cavities



RI Germany



Z Italy



DESY Germany

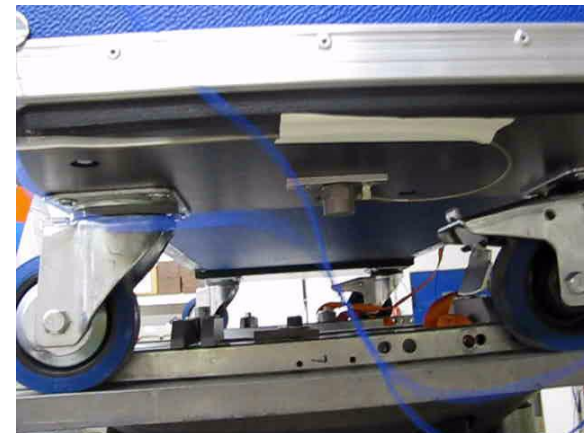
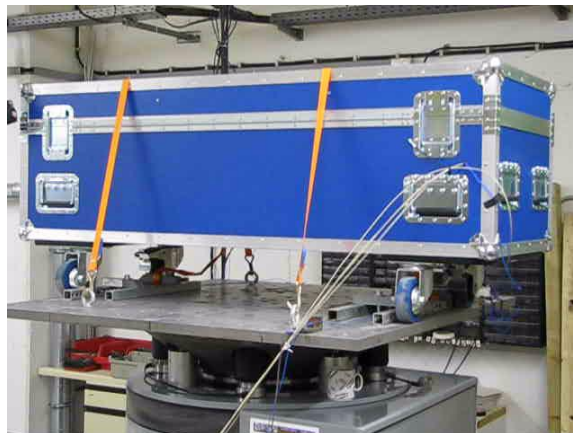
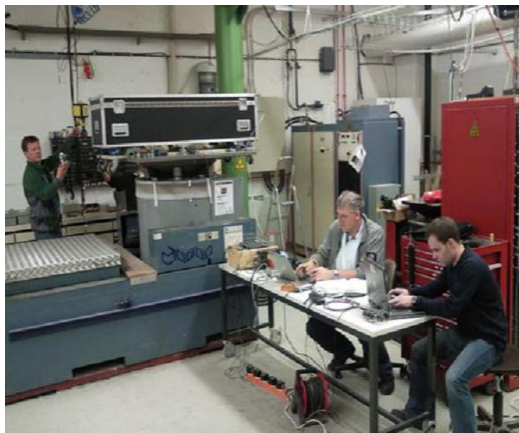
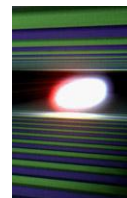


IRFU /CEA France

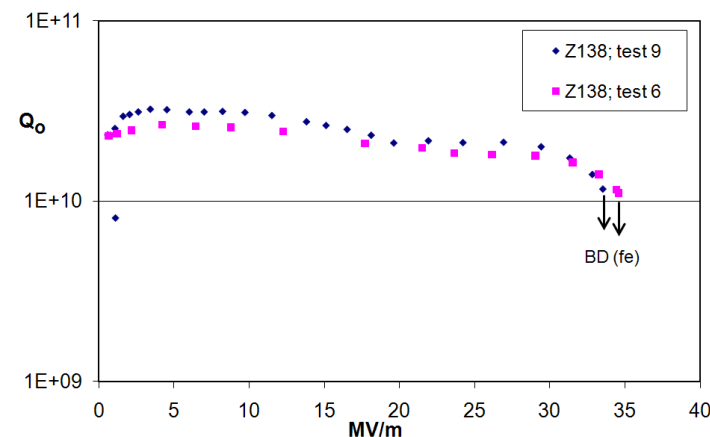
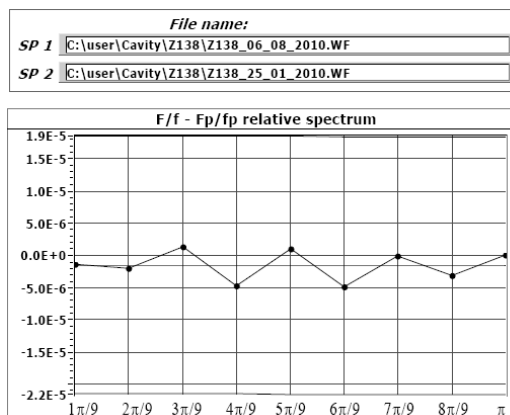
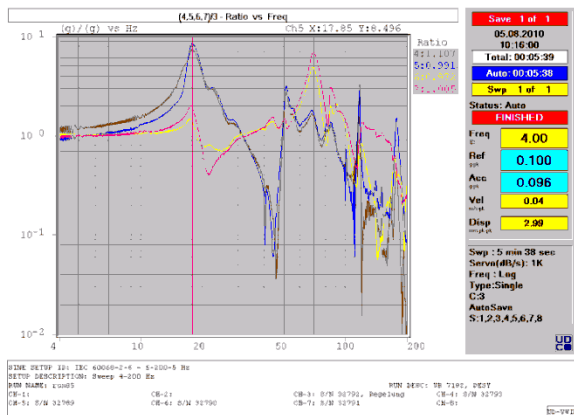


- DESY takes care of installation / dismounting of cavities into / from test insert
- Transport to CEA in transport boxes as well

# 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.



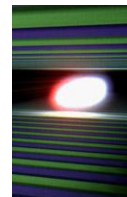
■ Eigen frequencies

■ Field flatness

■ Cavity gradient



# Cavity String & Module Assembly

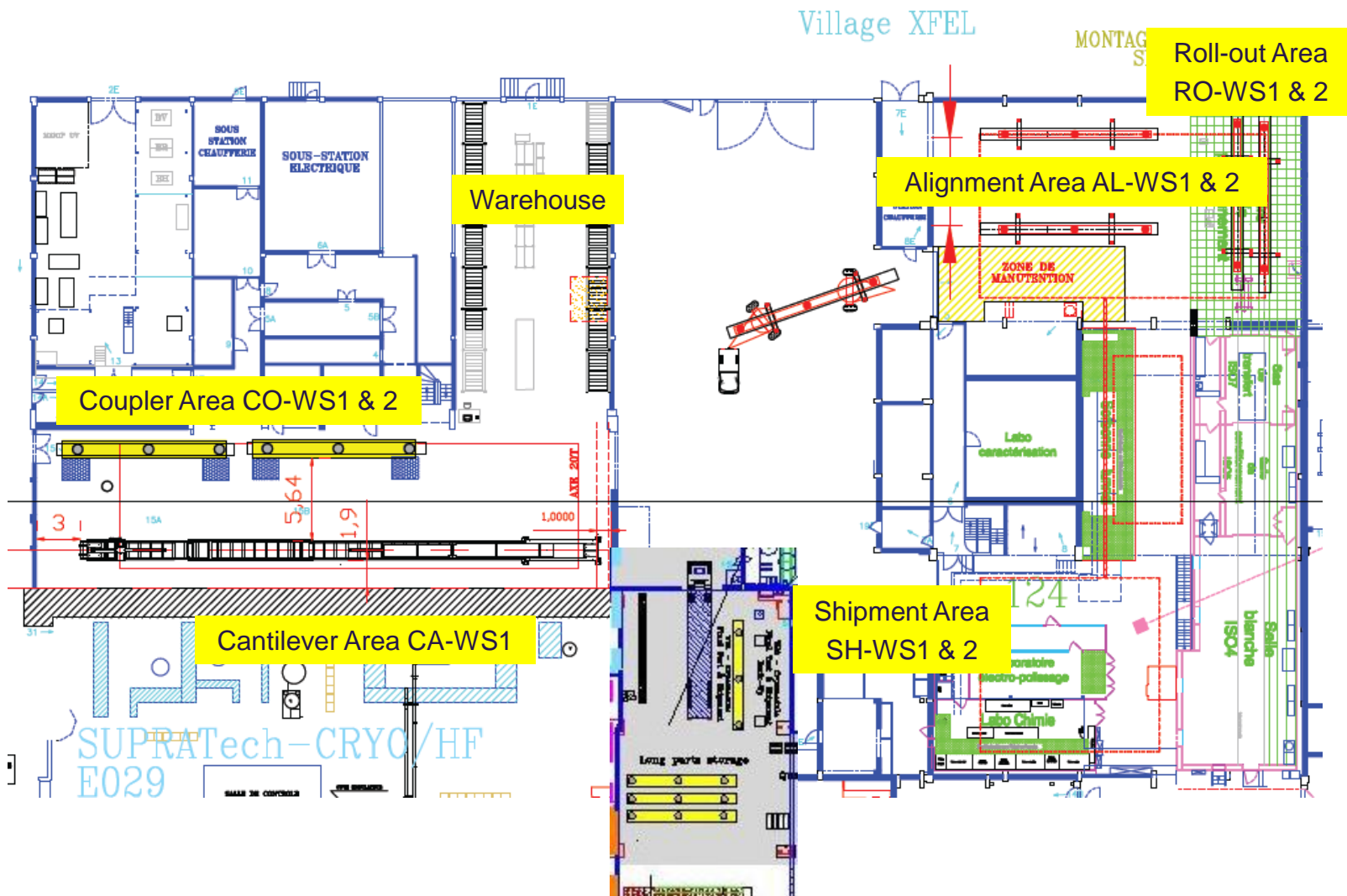
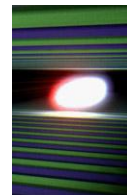


■ Using experience gained at DESY and results of industrial studies, the assembly facility for all XFEL modules will be set up at the CEA-Saclay site.

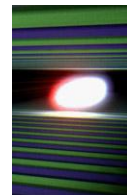
■ CEA (IRFU), CIEMAT, DESY, INFN-Milano, LAL Orsay, Swierk take the responsibility for the cold linac.



# Module Assembly - Workstations

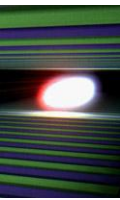






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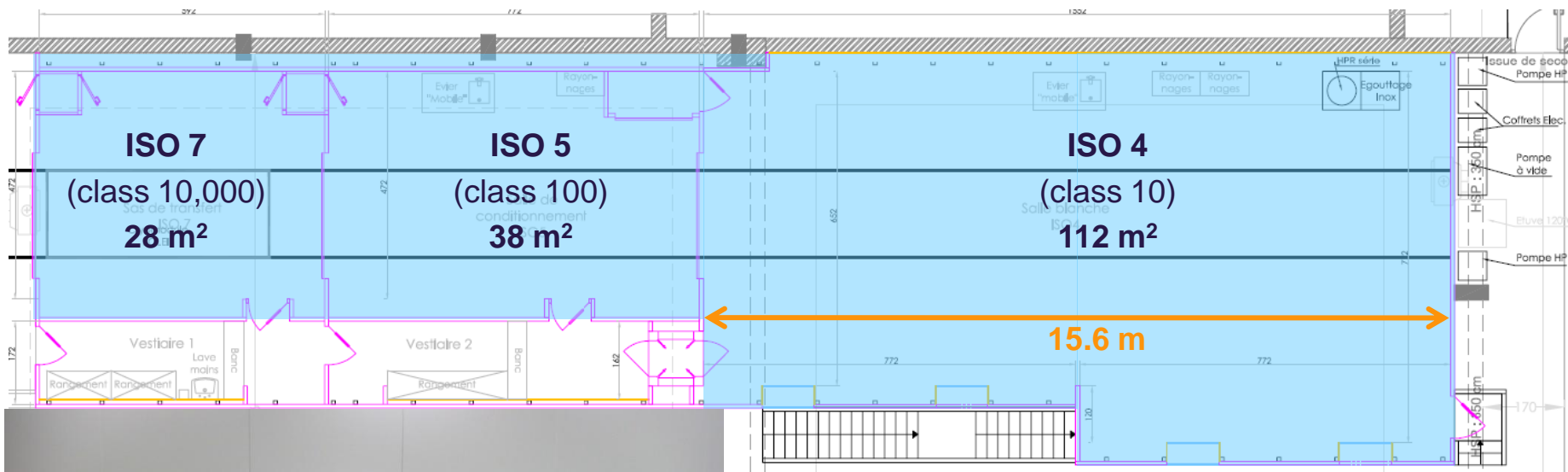
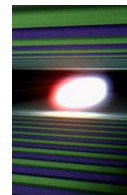
# Infrastructure for Cavity String Assembly



i r f u  
—  
cea  
—  
saclay

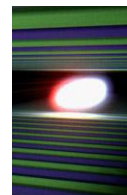


# Infrastructure for Cavity String Assembly



irfu  
cea  
saclay

# 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)

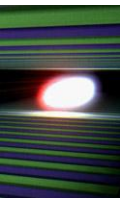
**Assembly Hall and Services ready: April 2010**

**Central courtyard re-surfaced in June 2010.**





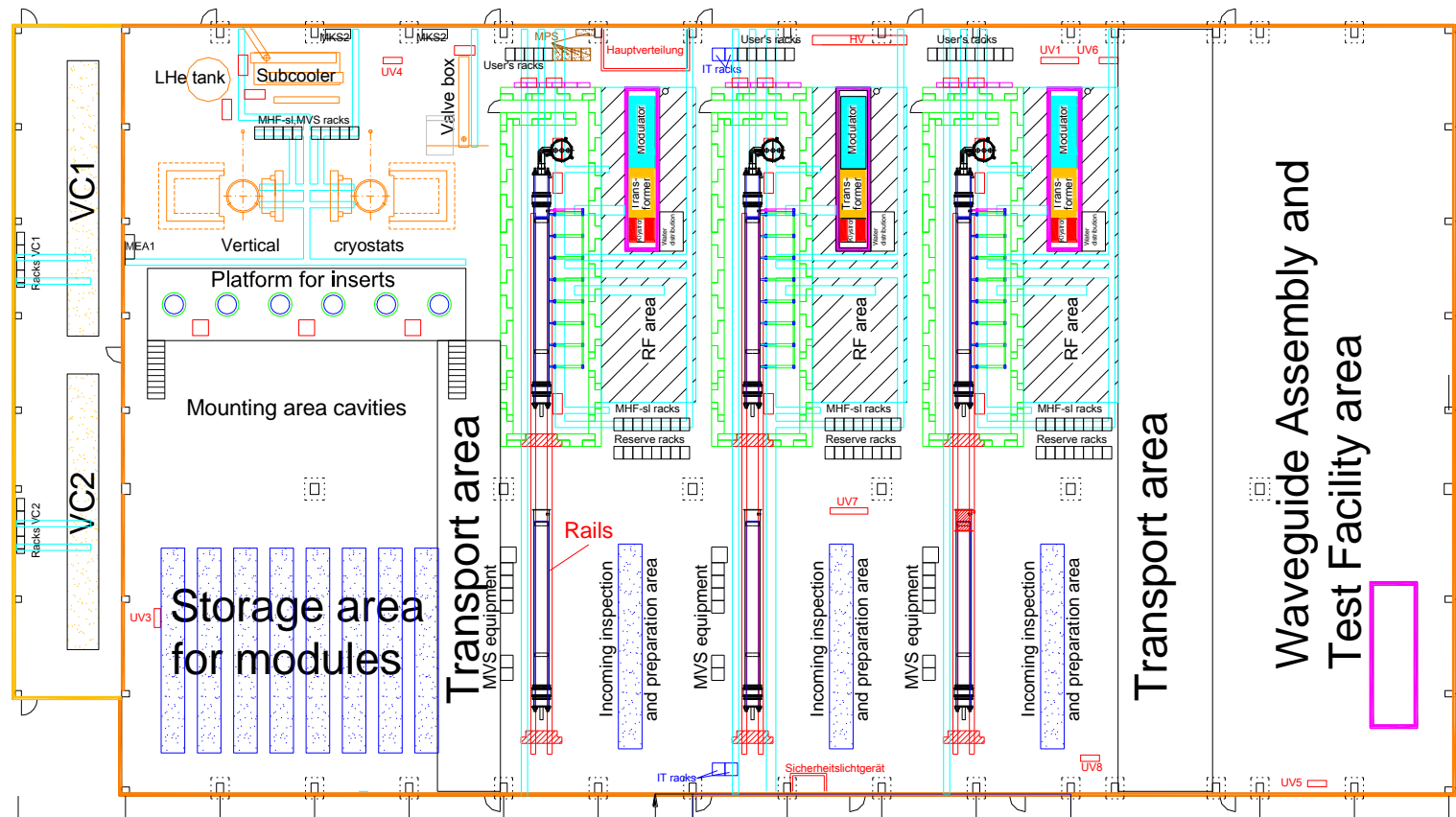
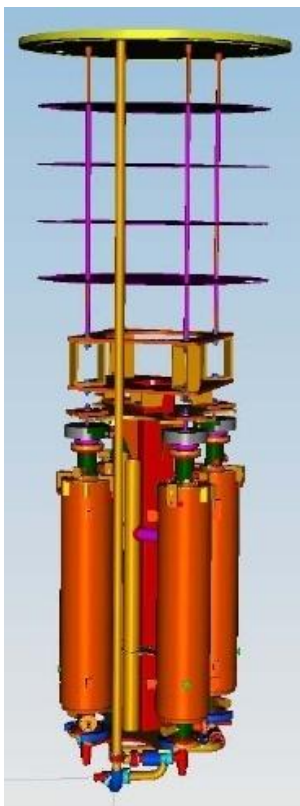
# Refurbished DESY Clean Room



- 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

# Accelerator Module Test Facility (AMTF) Including Single Cavity Tests

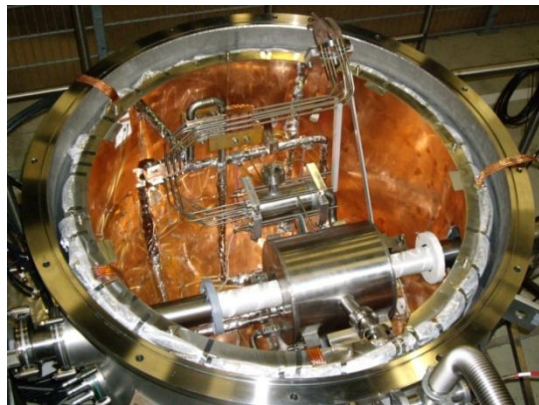
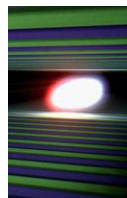


- Includes cavity / module  
& waveguide assembly / test

- Commissioning
  - cavity tests late fall 2011
  - module tests end 2011



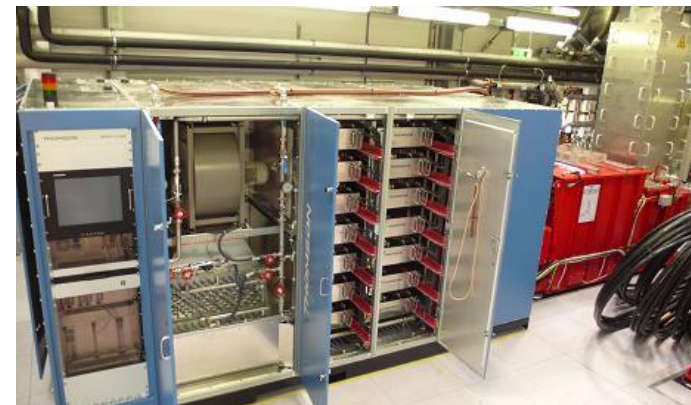
# Many More Components, e.g. Cold Magnets, 3.9 GHz Acceleration, RF Systems ...



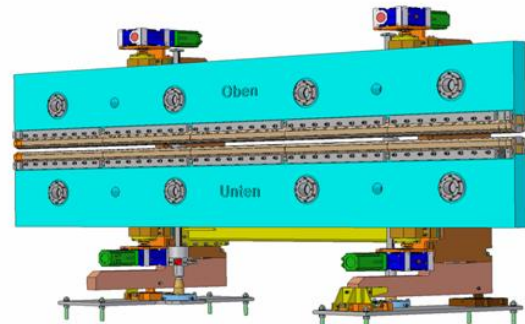
■ The first **cold magnet** in the test cryostat.



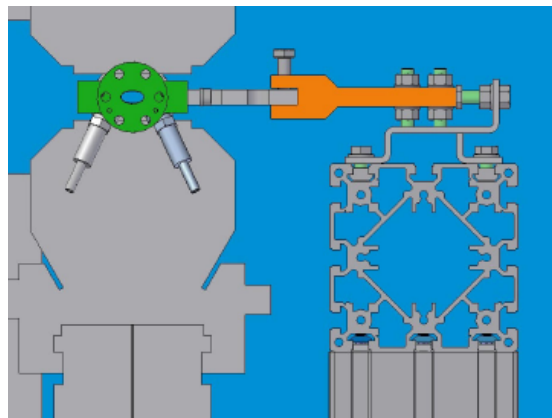
■ The **3.9 GHz FLASH** accelerator module as prototype.



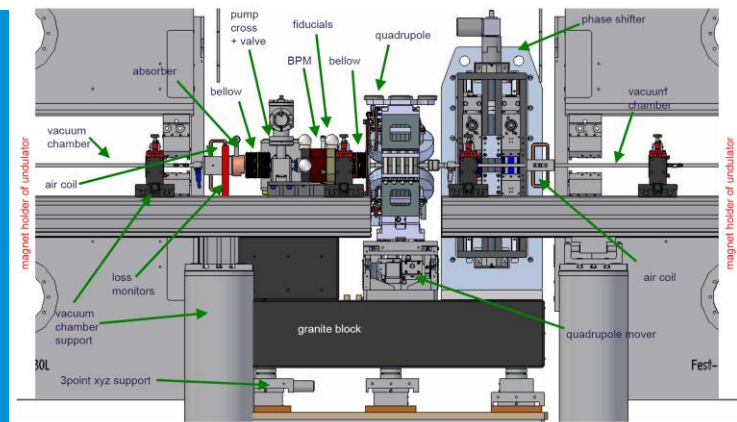
■ **RF system R&D** at DESY.



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

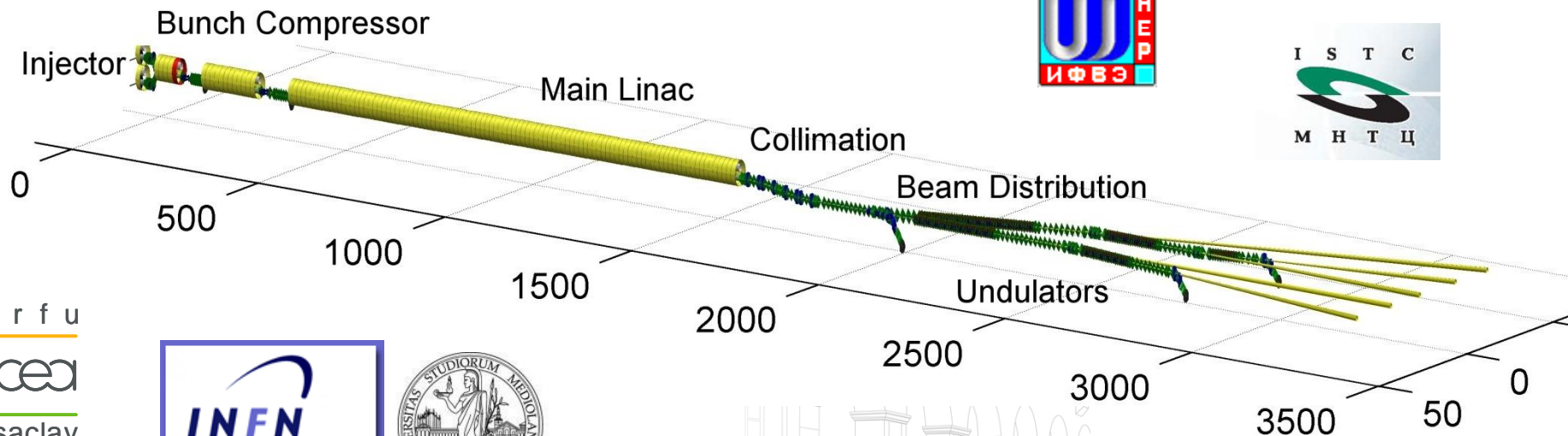
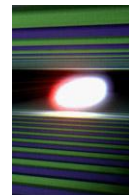


■ Undulator beam pipe extr. Al 15 mm x 8.8 mm ellipsoid



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

# Many Contributions to the Accelerator Complex



irfu  
cea  
saclay



Wrocław University of Technology



In2p3



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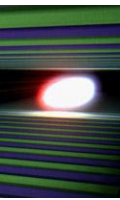


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■ The end