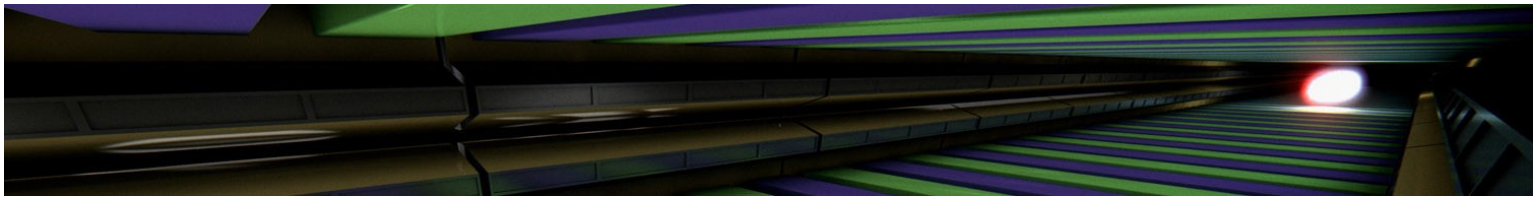


European XFEL Users' Meeting 2011 -
HASYLAB Users' Meeting 2011

26-28 January 2011 *DESY, Notkestr. 85, 22607 Hamburg, Germany*

Europe/Berlin timezone

The Electron Accelerator of the European XFEL

Hans Weise / DESY

HELMHOLTZ ASSOCIATION

European XFEL

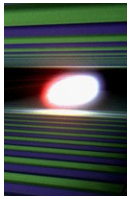
The First Tunnel

DESY

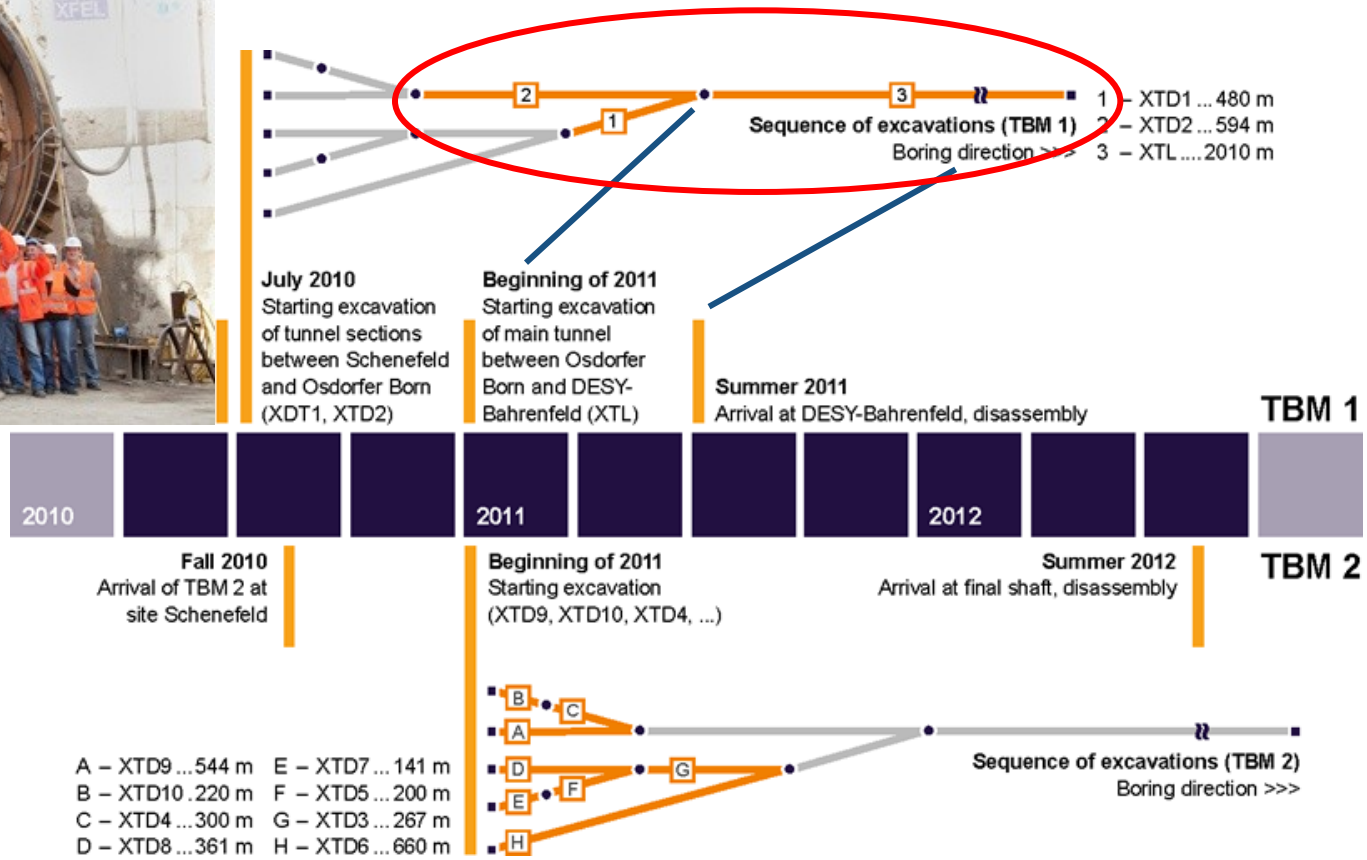
HELMHOLTZ ASSOCIATION

European XFEL

480 m within the First two Months



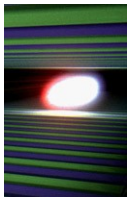
- Starting excavation of main linac tunnel beginning of 2011
- Arrival at DESY Bahrenfeld (injector) in summer 2011



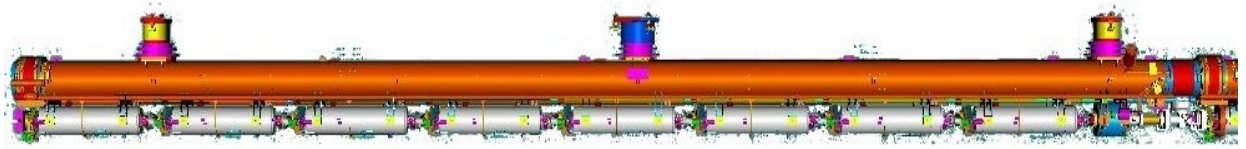
European XFEL

The Injector Building

Accelerator Complex Start-up Version

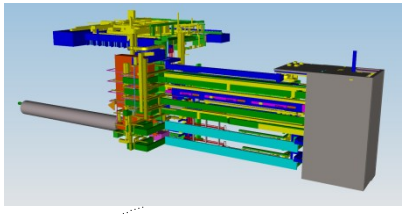


100 accelerator modules



800 accelerating cavities
1.3 GHz / 23.6 MV/m

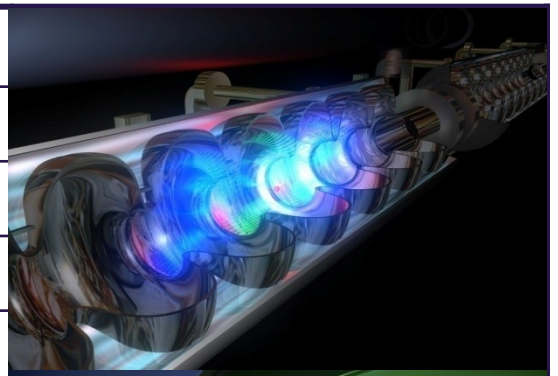
25 RF stations
5.2 MW each

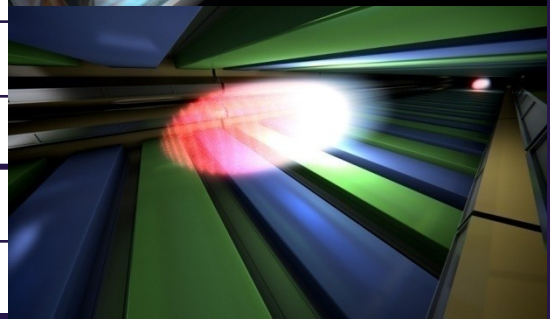


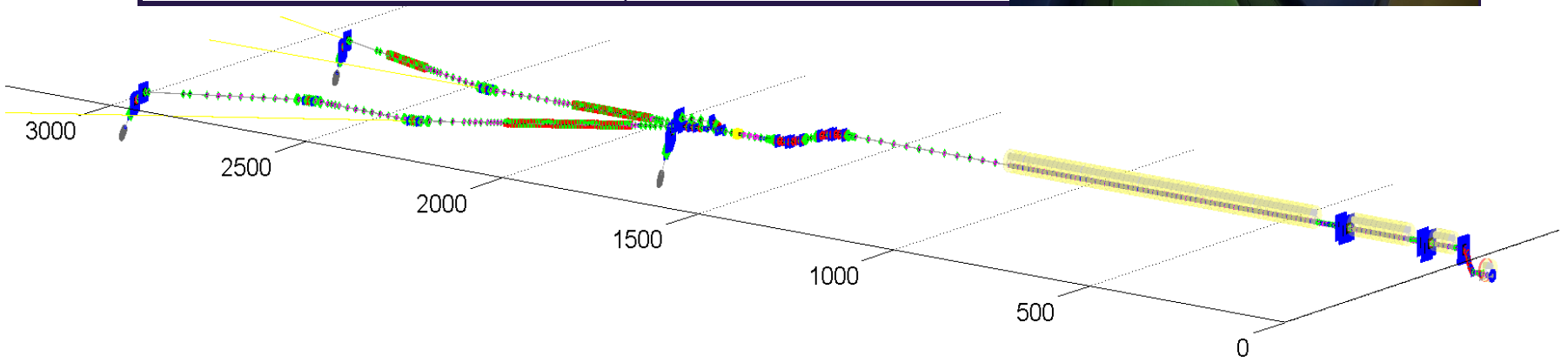
European XFEL

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





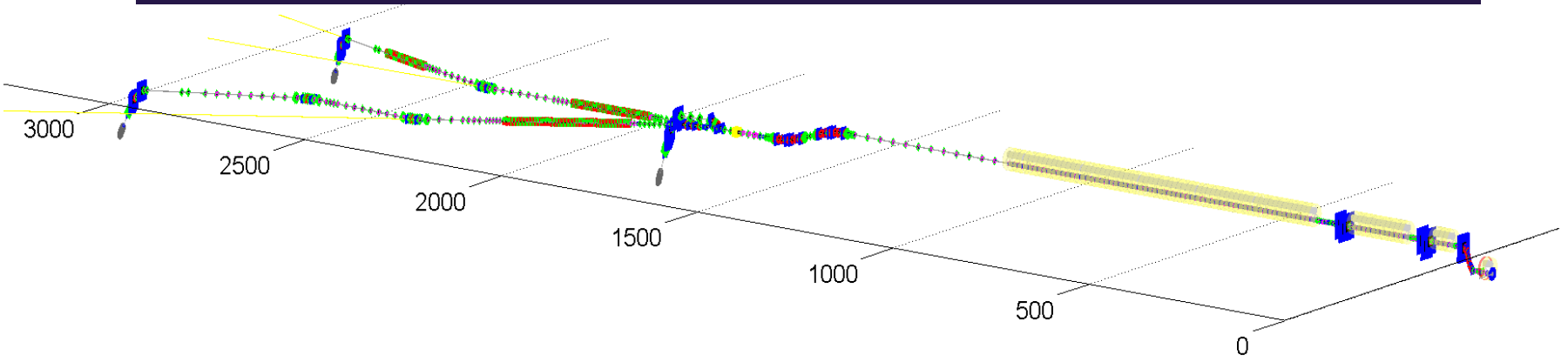


DESY HELMHOLTZ ASSOCIATION

European XFEL

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

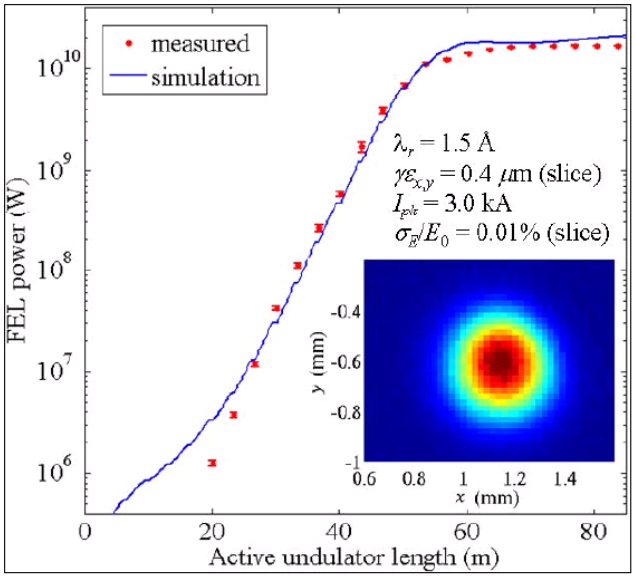


DESY HELMHOLTZ ASSOCIATION

Results from LCLS

0.25 nC

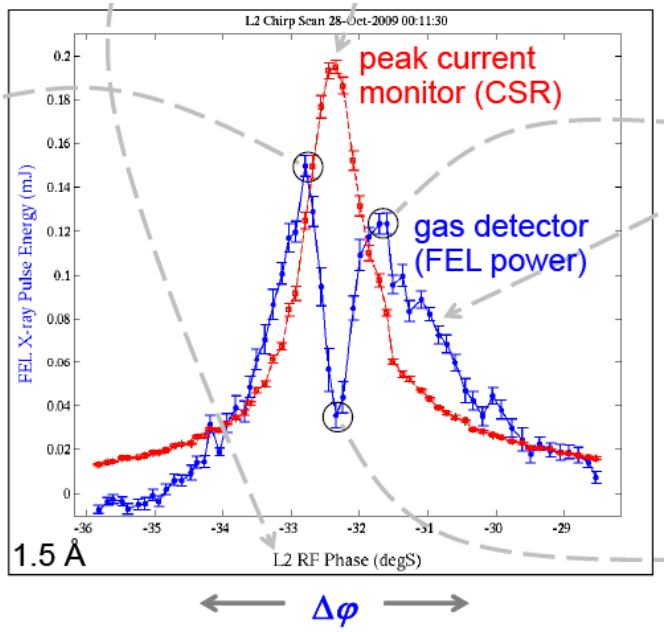
Saturation after 65 m



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

20 pC

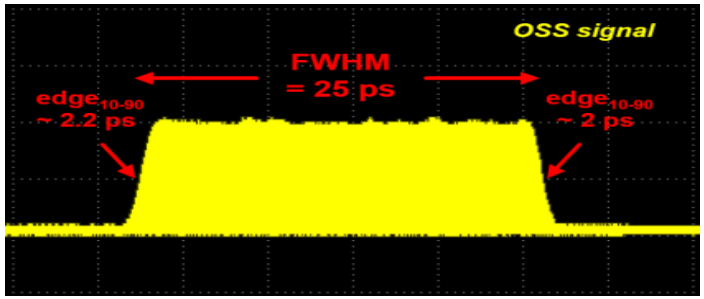
X-ray pulse should be < 10 fs (no measurement possible yet)

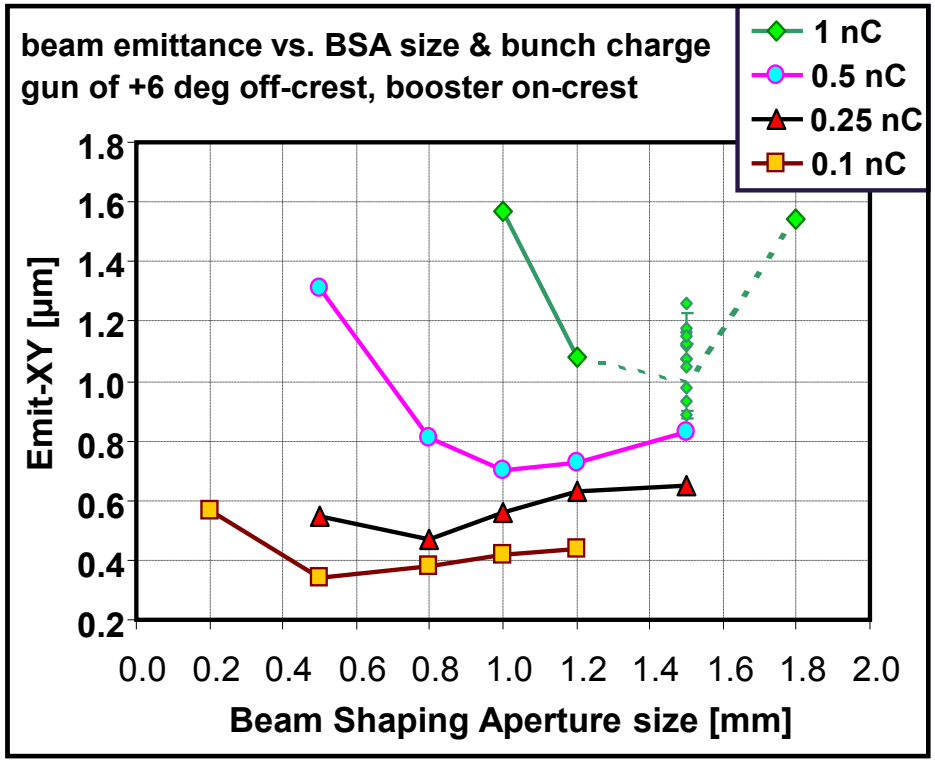


Consequences for the European XFEL

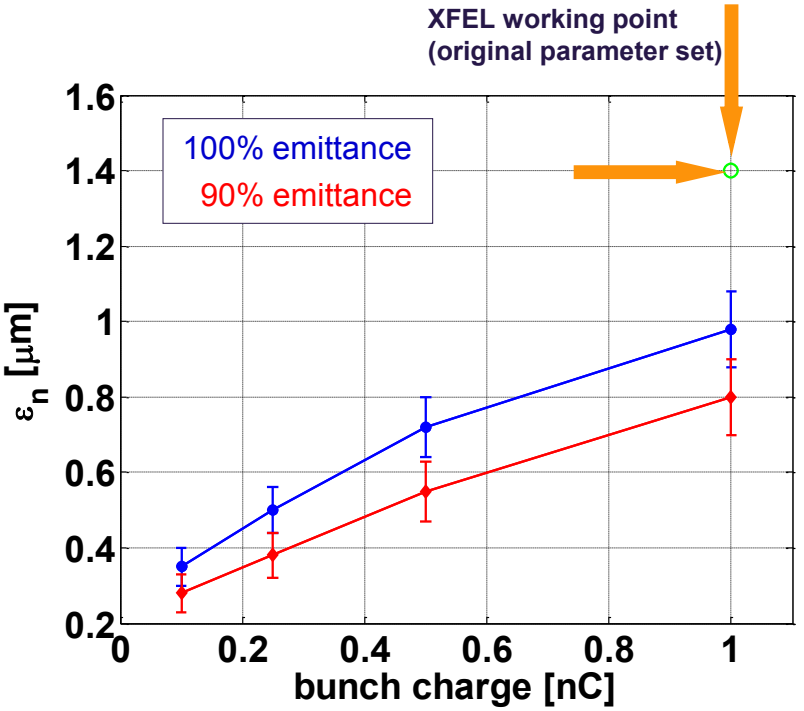
- SASE with electron beam parameters as simulated => safety margins can be reduced
- Operation at low charges with strong compression feasible => include scheme from beginning

DESY PITZ Results on Emittance

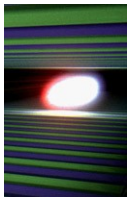




Measured projected emittance versus bunch charge

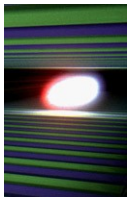


Possible Shortening of the LINAC

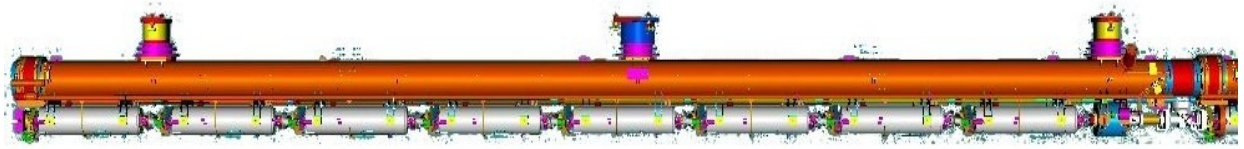


- Improved beam quality **gives possibility to save money** by shortening the linac while keeping the baseline performance.
- Extensive simulations support the new parameter set.
- **BUT:**
  - Reduced safety margin
  - Reduced photon energy reach
  - Makes eventual later conversion to cw more expensive
- 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

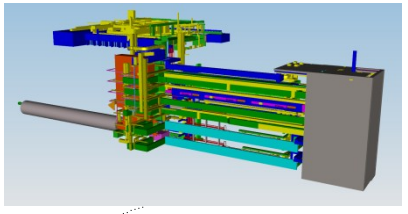


640 accelerating cavities

1.3 GHz / 24.3 MV/m

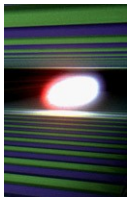
20 RF stations

5.2 MW each



Cavities

Cavities – The Contracts

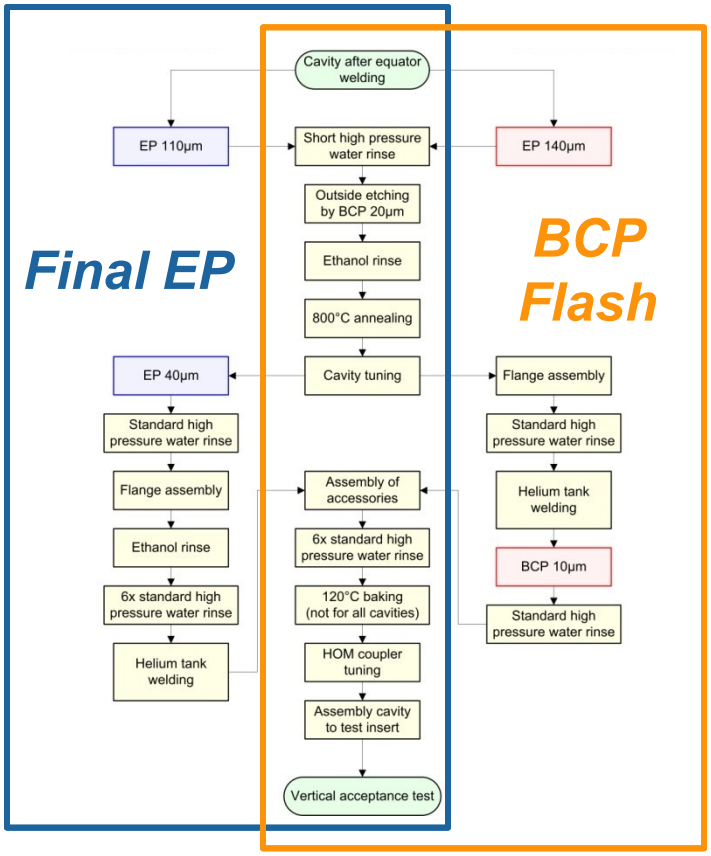


- **Research Instruments and E. Zanon** were contracted **to produce each**
  - 4+4 **pre-series cavities**
  - **280 XFEL type series cavities**
  - **12 HiGrade cavities**, first used for quality assurance, later available for further investigations & treatments (high gradient R&D towards ILC)
  -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

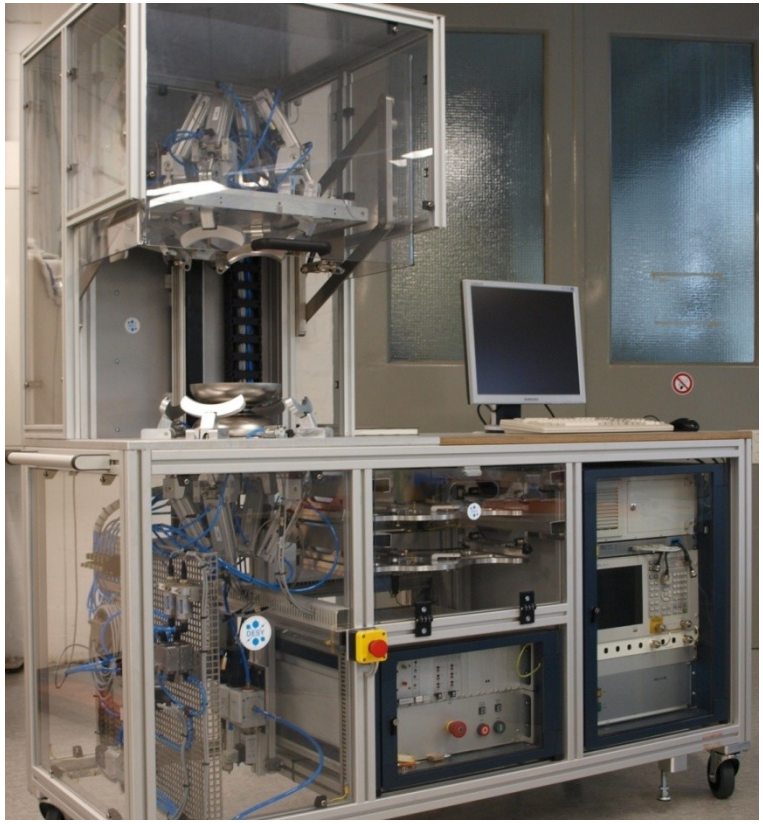
Cavity Surface Treatment – Based on DESY Experience

- **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.



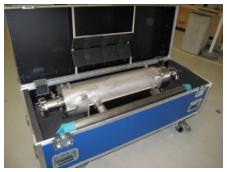
- **Results** are:
  - yield curves for the different schemes
  - yield curves for the different vendors
  - a preparation strategy allowing two different final treatments
- Some **tooling** will come from DESY
- **DESY procedures and experience** described very much in detail in the CFT
- Specification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

RF Measurement and Field Flatness Tuning using DESY-provided Tools



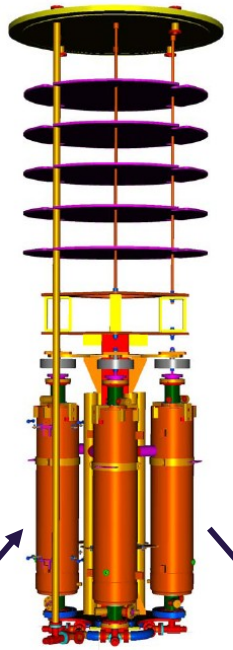
- Both machines ready to be used at the companies (CE certified).
- Machines can be operated by Non-RF-Experts.
- **Considerably shorter measurement / tuning time.**
- Automation and documentation guaranteed.

Transport Solution for XFEL Cavities



RI Germany

Z Italy



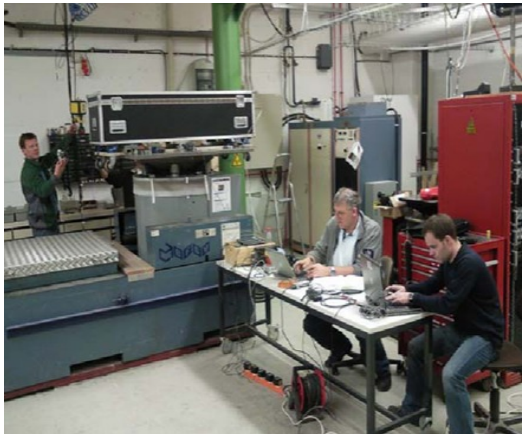
DESY Germany

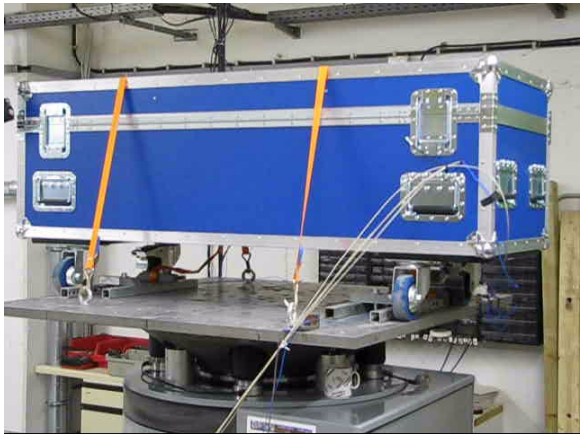
IRFU /CEA France

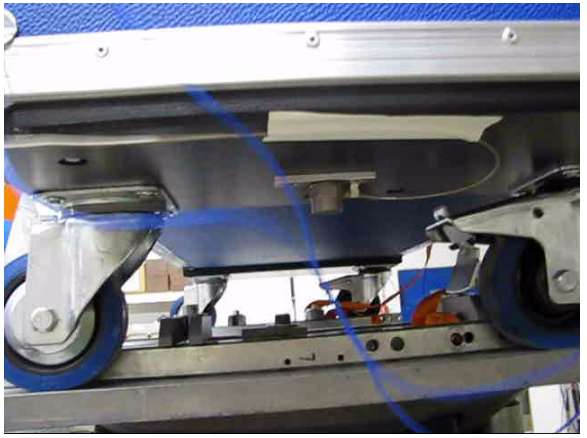
- DESY takes care of installation / dismounting of cavities into / from test insert
- Transport to CEA in transport boxes as well

European XFEL

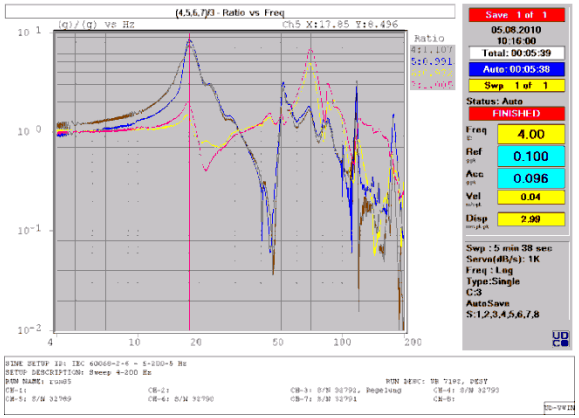
Transport Simulation

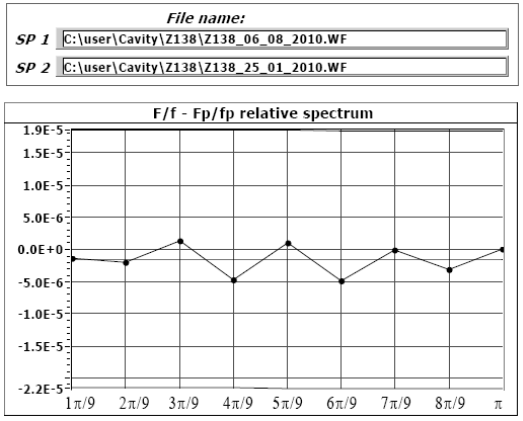


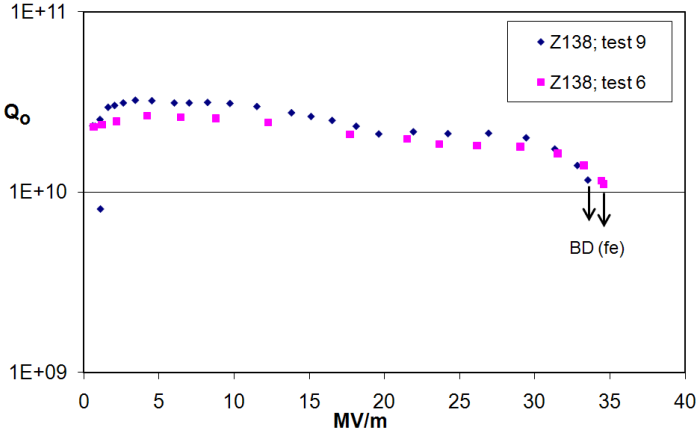




- Sweep (0.1 g), Transport simulation (up to 2 g) 1200 km with Shocks applied up to 6 g
- Final test done without external dampers, only internal foam elements.



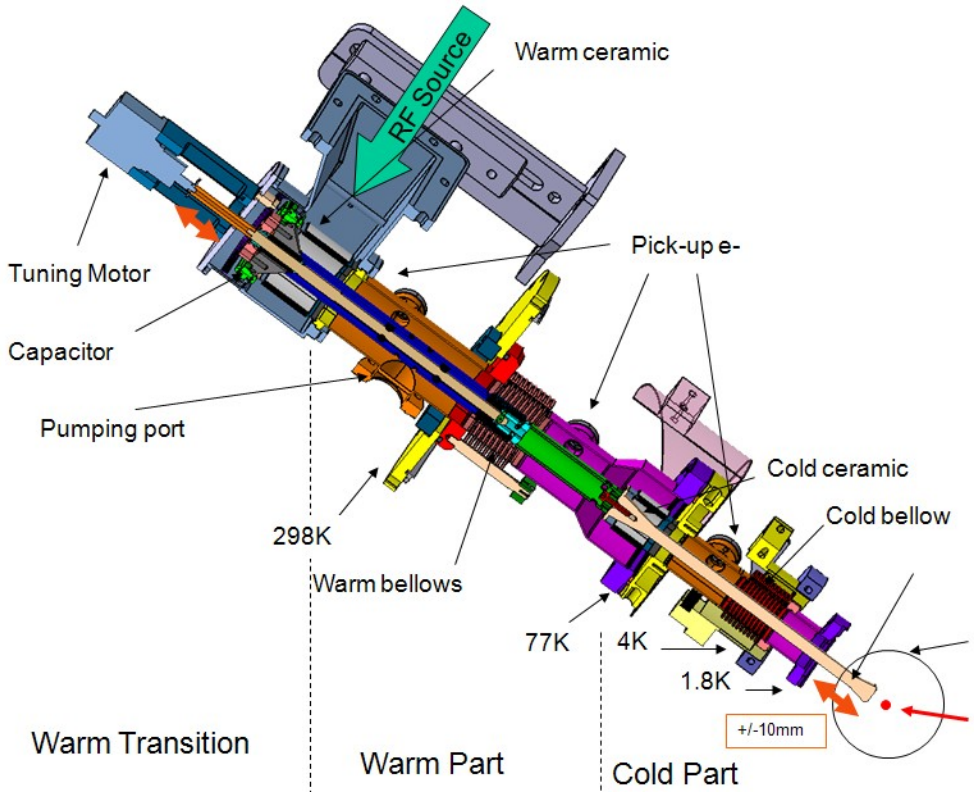




- Eigen frequencies
- Field flatness
- Cavity gradient

DESY HELMHOLTZ ASSOCIATION

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.**

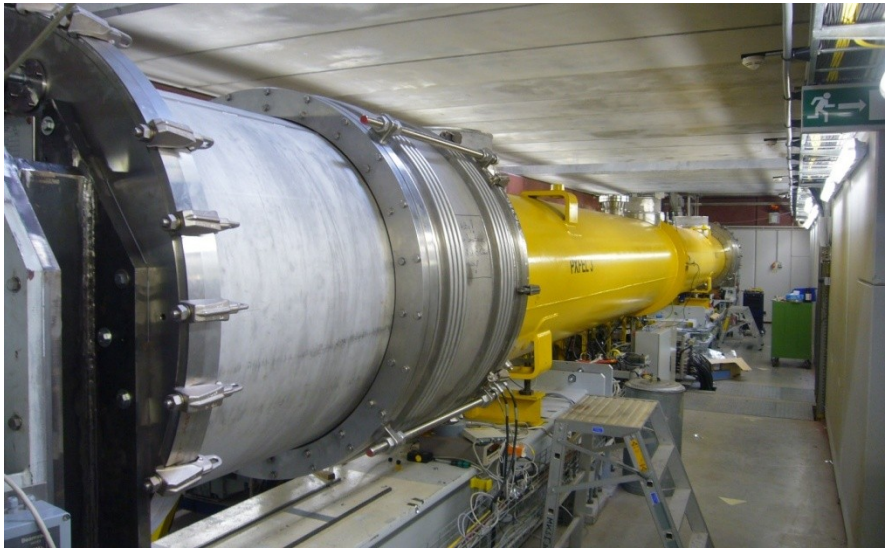
XFEL RF Power Coupler – Conditioning at LAL

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.

Detailed Planning of required LAL Clean room

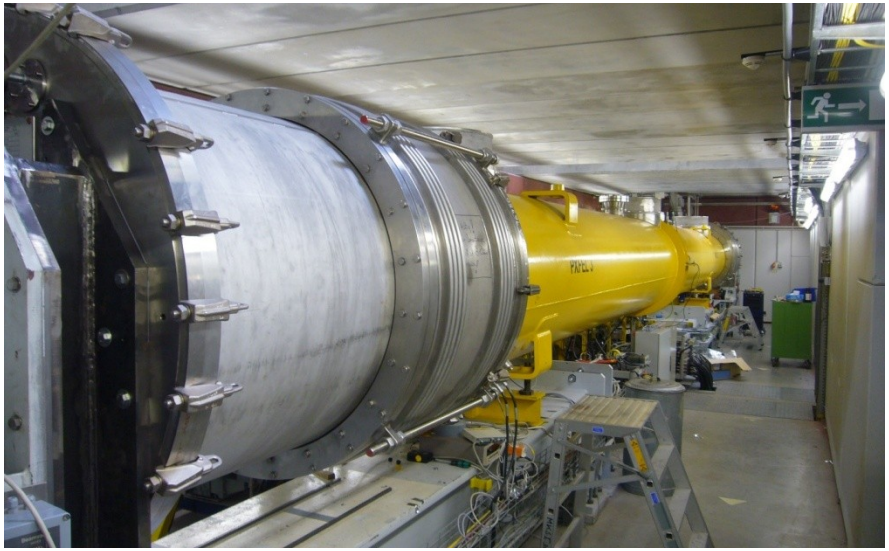
PXFEL – Three Modules from Different Vendors



- Three XFEL prototype modules were built and tested over the last two years.
- 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

Institute of High Energy Physics
Chinese Academy of Sciences

PXFEL – Modules from Different Vendors

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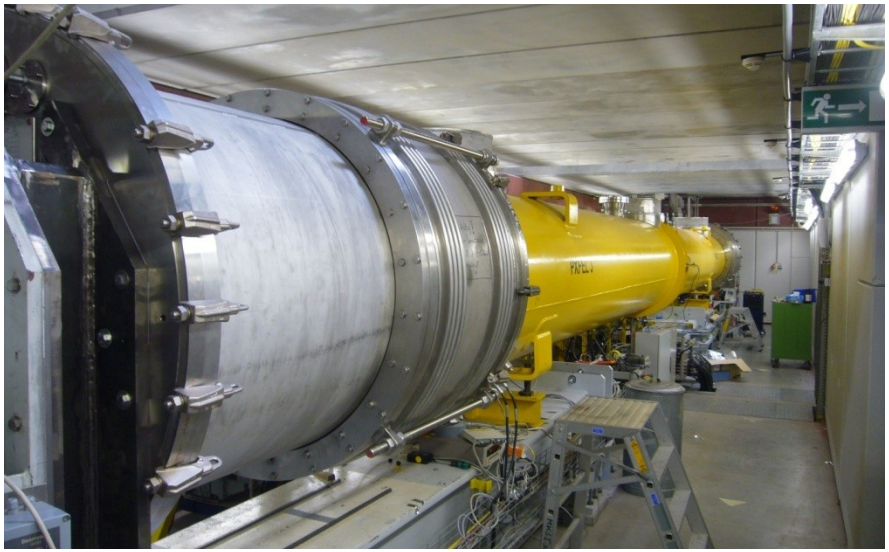
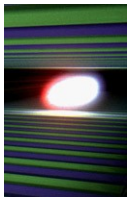


- PXFEL2: av.gradient 29.6 MV/m
- **BUT:** 3rd cavity dropped from 27 down to 16 MV/m and neighboring cavities show field emission.
- Looks like an assembly problem but no hint in the reports**. Module was used for string & module assembly training.** Investigations ongoing.

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

PXFEL – Modules from Different Vendors



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- 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 successfully **tested**.
- **Cryogenic losses & gradients are ok.**
- Result: XFEL module performance reached although again one problematic cavity.
- **Improved current leads** were used for sc quadrupole magnets.

- 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.** Investigations ongoing.

- 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 has published the Call for Tender**, contracts to be placed in the next weeks**.

E. ZANON SINCE 1919

Institute of High Energy Physics
Chinese Academy of Sciences

duro felguera, s.a.

THALES

European XFEL

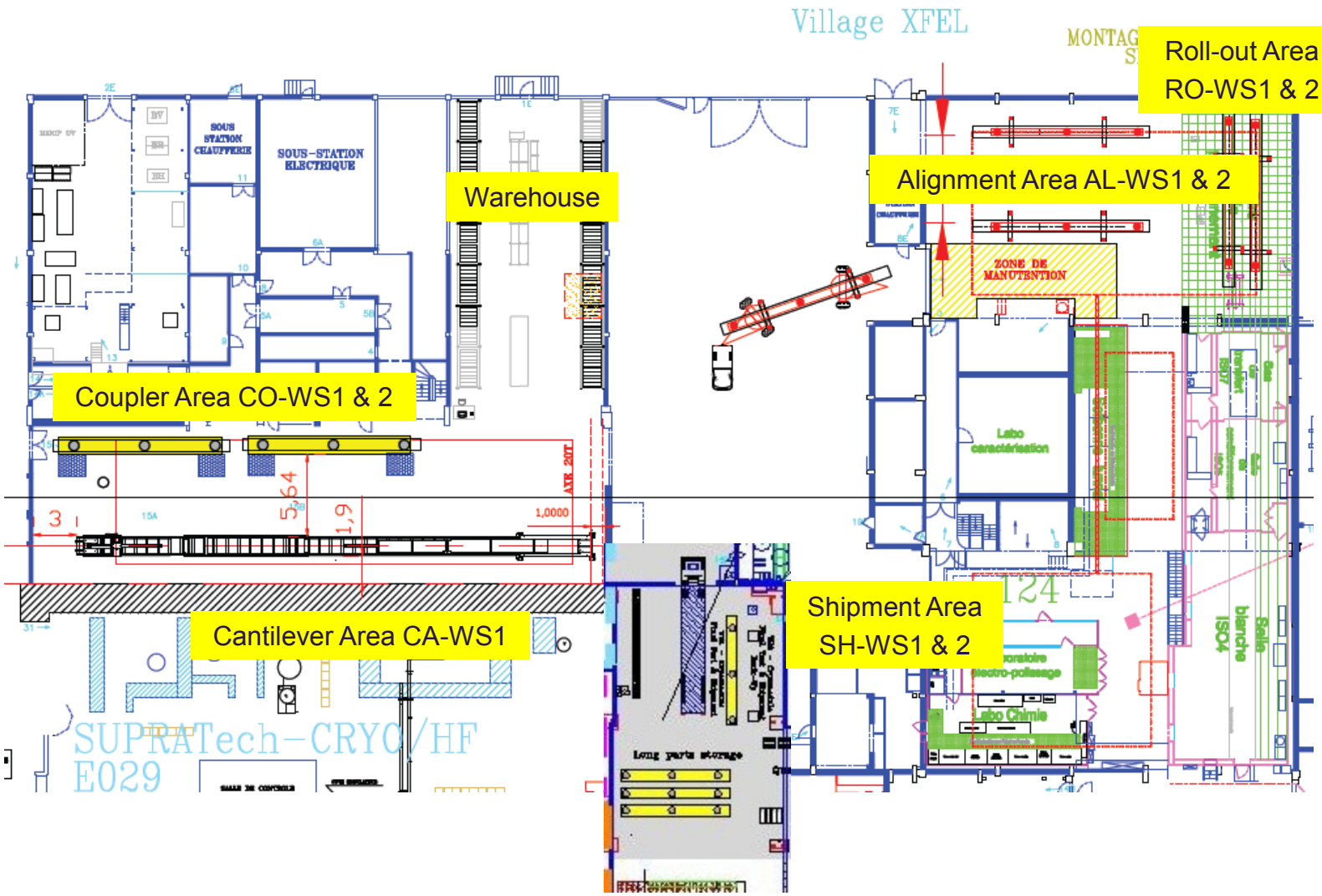
Cavity String & Module Assembly

- 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

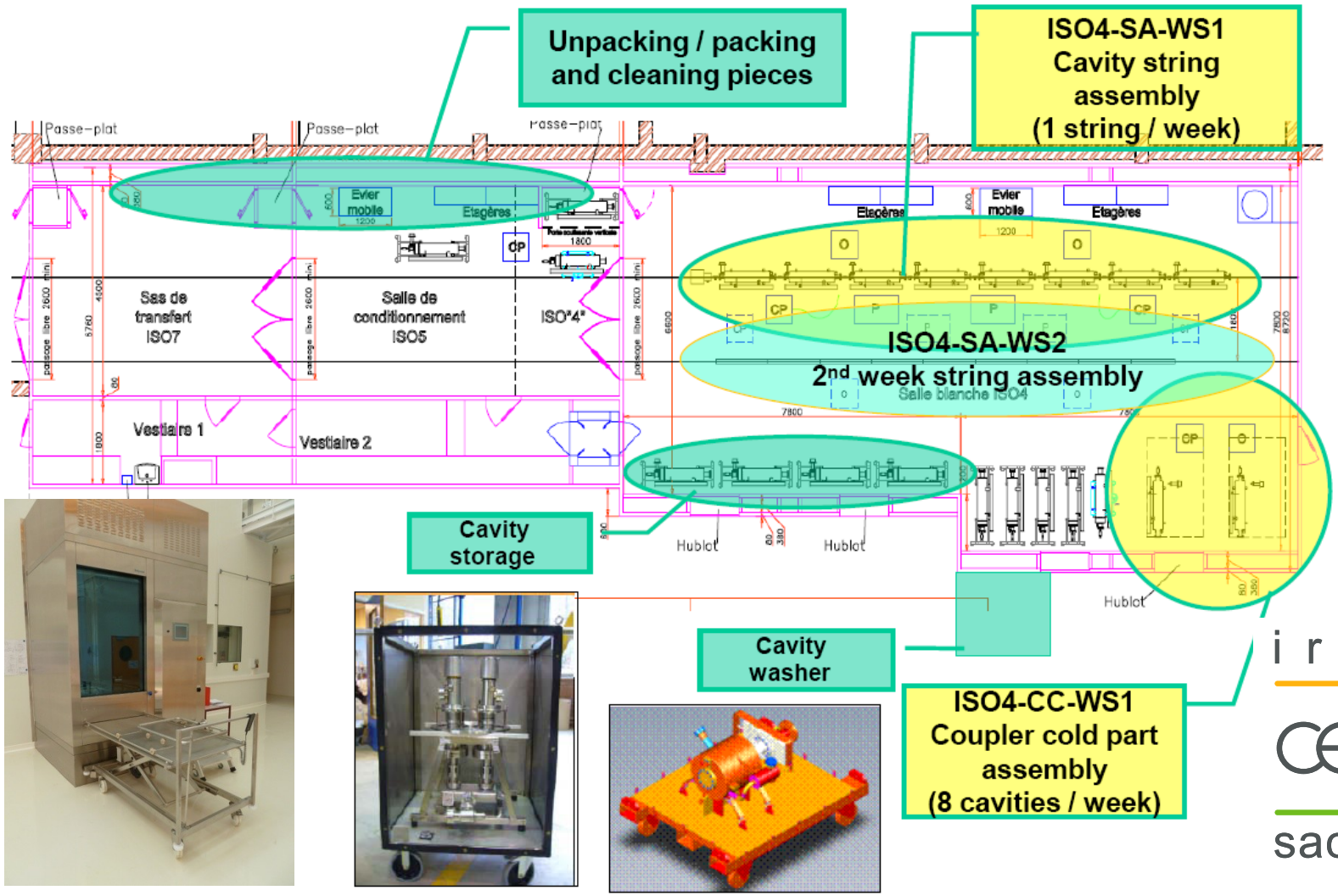
Module Assembly - Workstations



irfu cea saclay

DESY HELMHOLTZ ASSOCIATION

String Assembly - Workstations



- 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

irfu

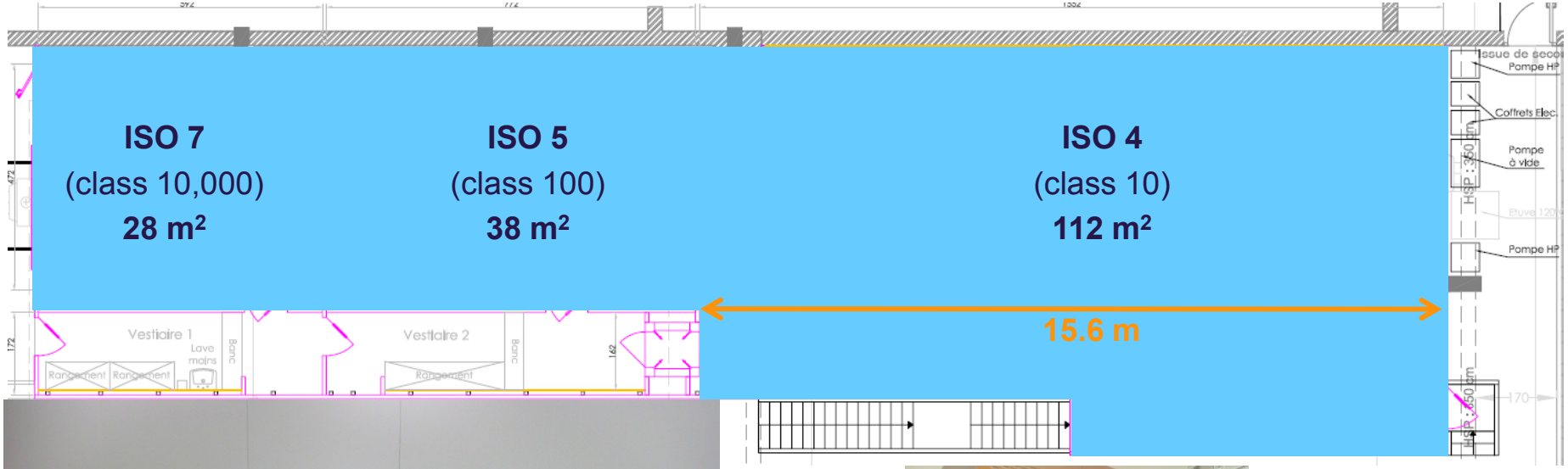
cea

saclay

DESY

HELMHOLTZ ASSOCIATION

Infrastructure for Cavity String Assembly



irfu
cea
saclay

DESY HELMHOLTZ ASSOCIATION

Module Assembly Halls at CE Saclay

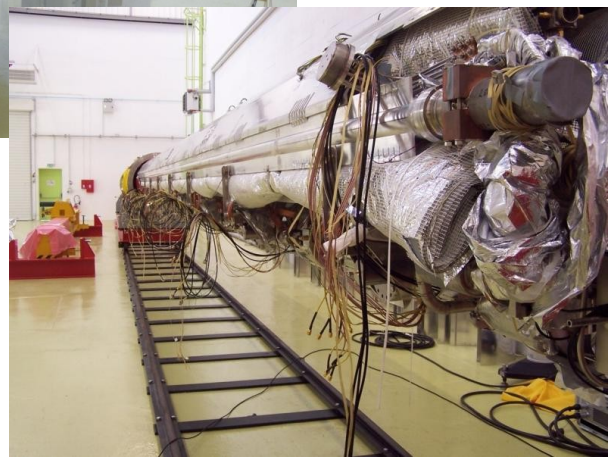
- Three Assembly Halls and Services (offices, dressing rooms, warehouse, central courtyard, etc…) were under rehabilitation:

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



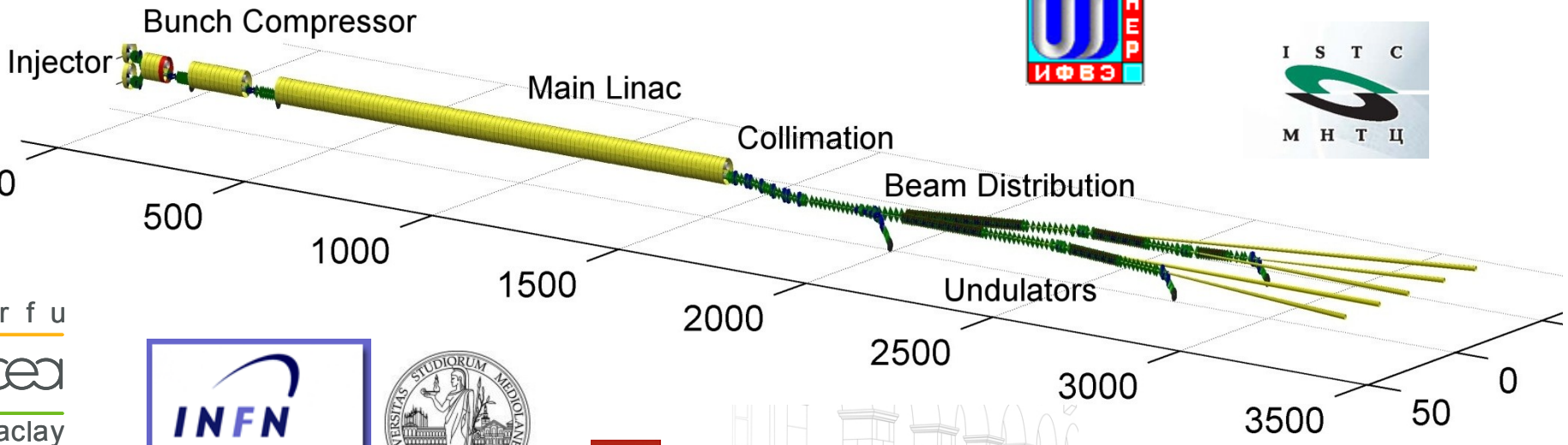
Refurbished DESY Clean Room

- Two independent air systems
- Improved energy balance

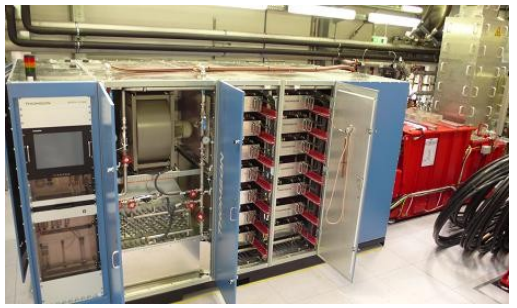
- State-of-the-art
- Now used for assembly training
- Later available for repair work

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

Many further In-kind Contributions to the Accelerator Complex



DESY In-kind Contributions



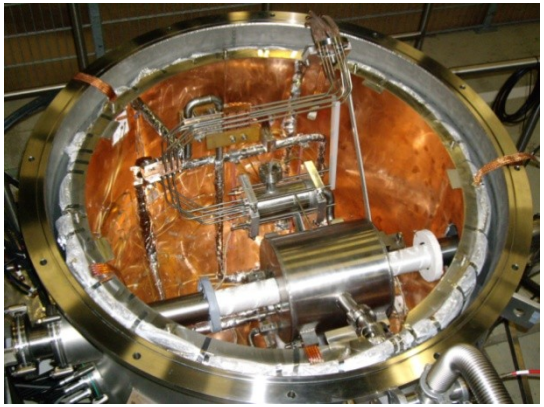
- **RF** system
  - klystrons, modulators, pulse transformers waveguide assembly & testing, overall coordination
- **LLRF** complete system
- Accelerator **Cryomodules**
  - Cold masses for Cryomodules (33 pieces)

- **Superconducting cavities**
  - 50% of cavities; 100% Nb/NbTi

- Power couplers
  - coupler interlock
- HOM couplers
  - overall coordination

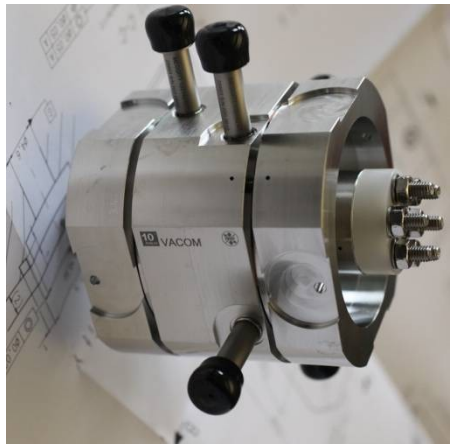
DESY In-kind Contributions

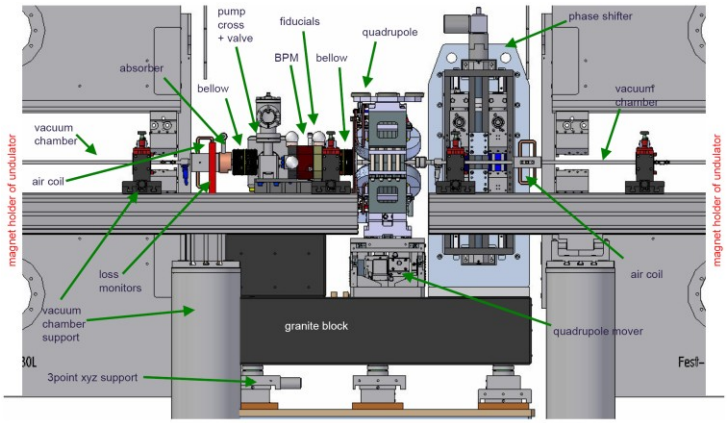
- Frequency **Tuner**
- **Cold vacuum** (approx. 75%)
- Cavity string assembly (approx. 20%)
- **AMTF cryogenics** (approx. 60%)
- Cold Magnets
  - magnet testing & current leads
- Warm Magnets
  - overall coordination
- **Cryogenics for Linac** (approx. 2/3)
- **Injector**
  - overall coordination and approx. 80% of hardware



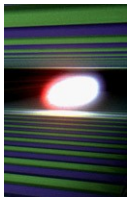
DESY In-kind Contributions

- **Bunch Compressor** Lattice
  - Beam Optics Design & Beam Distribution Kickers
- **BPM** system (approx. 50%)
- **Special Beam Diagnostics** (approx. 75%)
- **Warm vacuum** (approx. 80%)
- Beam dumps (approx. 25%)
- FEL Concepts
- **Control System**
- Operability
- Survey / Alignment





DESY In-kind Contributions

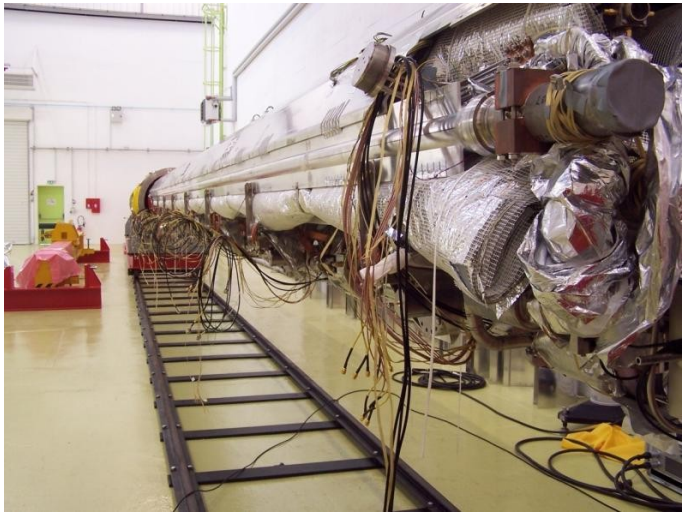


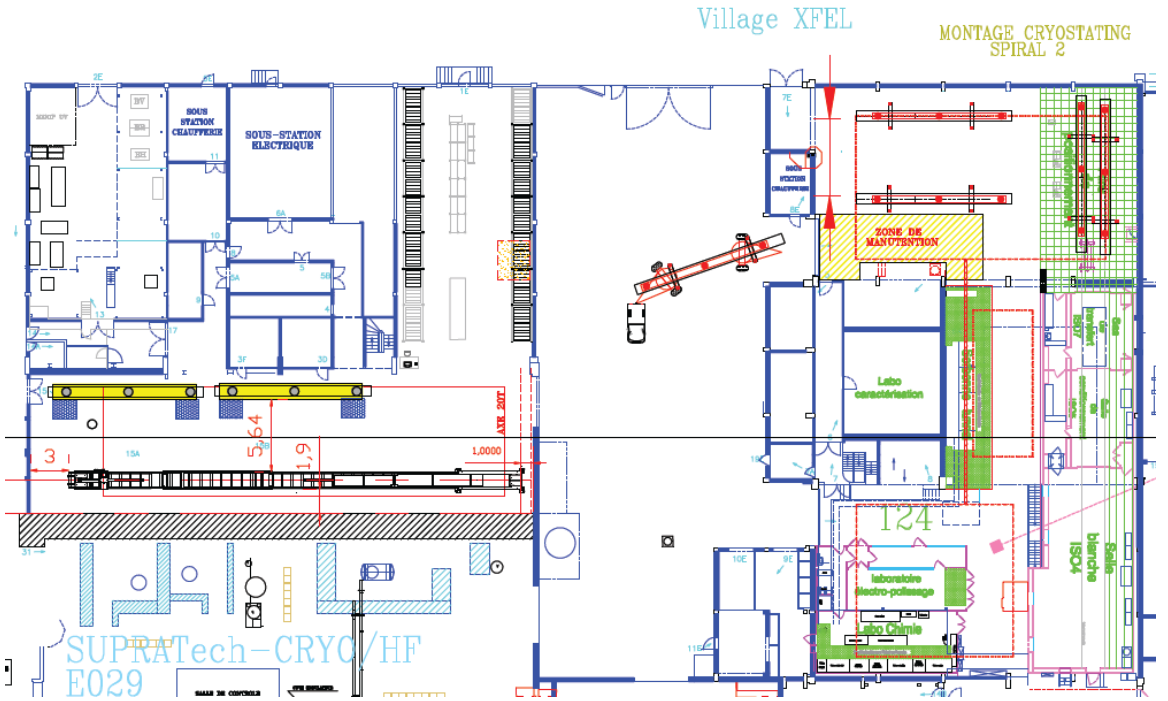
- Installation
- Utilities
- Radiation safety
- General safety
- Personnel interlock
- EMC
- Information & Process Support
- AMTF Hall
- 3.9 GHz system (approx. 2/3)

Saclay In-kind Contributions

irfu cea saclay

- cavity strings assembly
- cryomodules assembly
- BPMs system



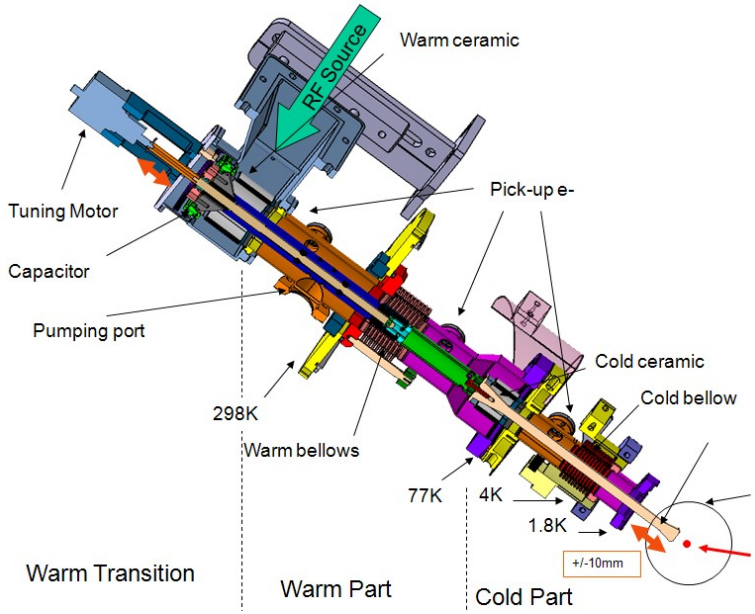


European XFEL

Orsay In-kind Contributions

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

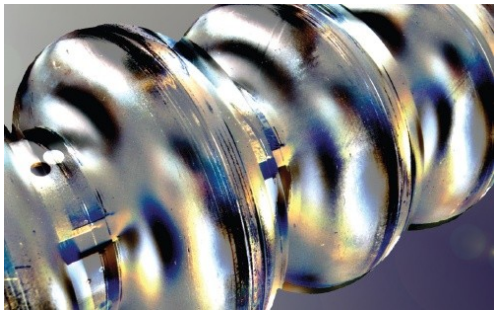
- Power couplers
  - procurement
  - RF conditioning

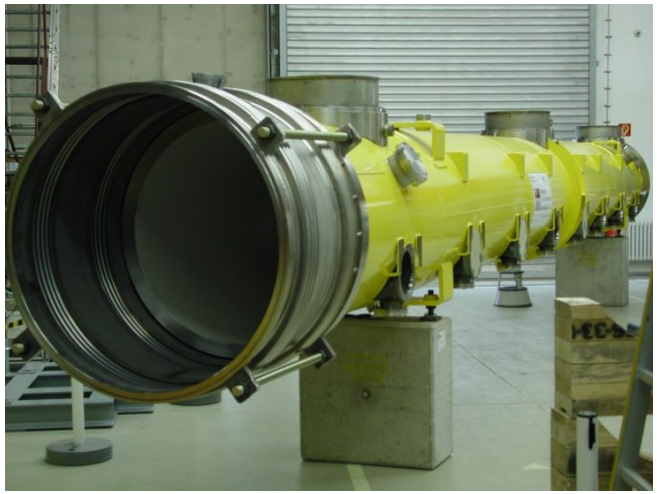


DESY HELMHOLTZ ASSOCIATION

INFN In-kind Contributions

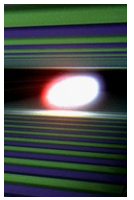
- Nb cavities (50%)
- Cold masses for Cryomodules (25%)
- 3.9 GHz accelerator module



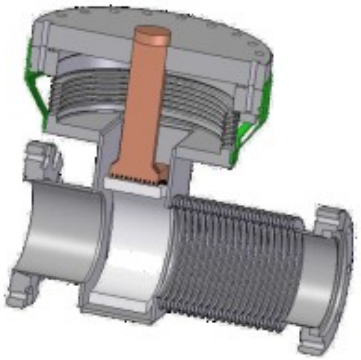


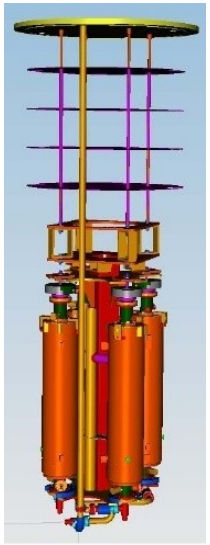
European XFEL

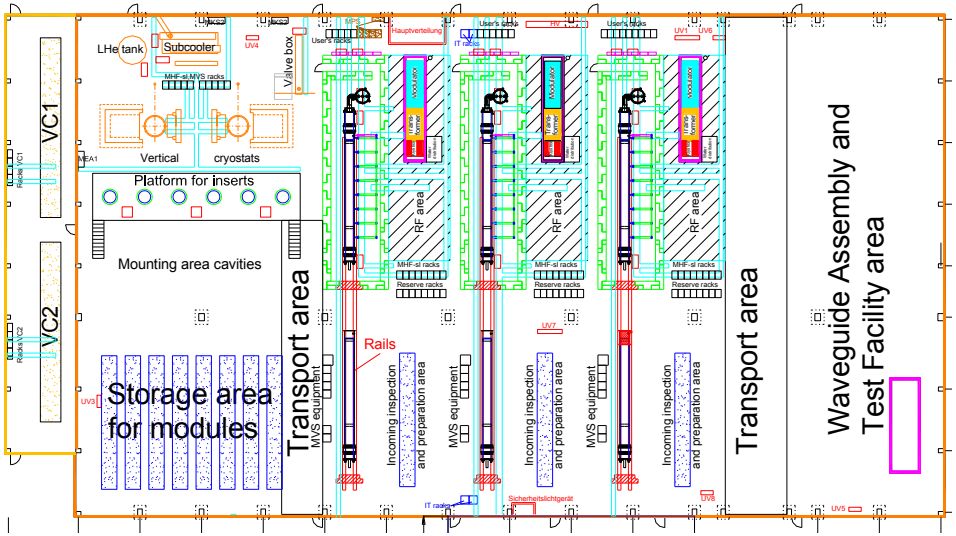
Polish In-kind Contributions



- **HOM couplers & absorbers**
- **Transfer lines** for AMTF
- **Tests** of Nb cavities
- **Tests** of cryomodules in AMTF
- **Tests** of Cold magnets

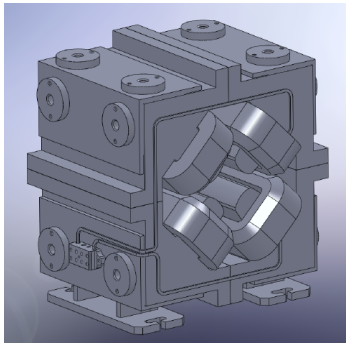


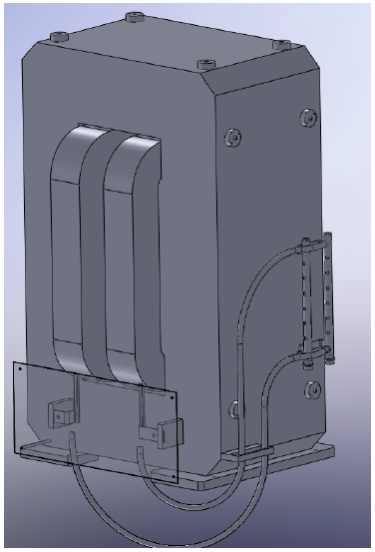


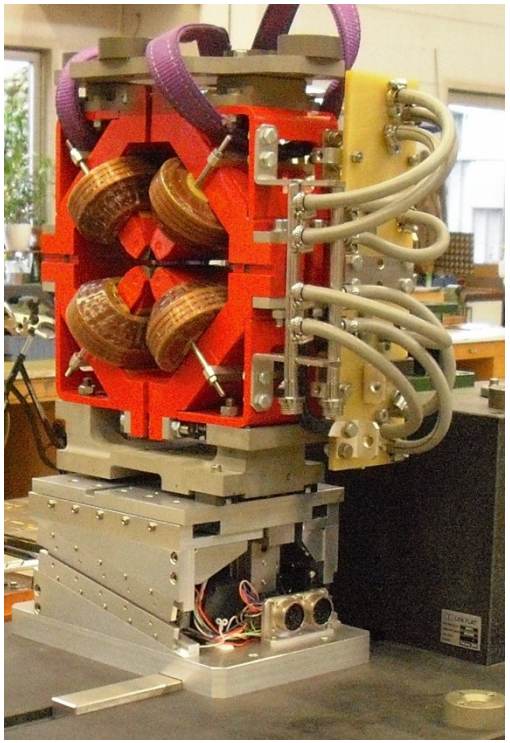


Russian “In-kind” Contributions

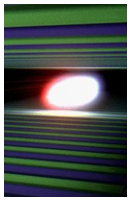
- **Cryogenics** for Linac
- **Beam dump**
- **Beam diagnostics**
- **Warm magnets**
- Connector module for Klystrons
- quadrupole magnets type XQA
- **Cold vacuum**
- Warm vacuum
- cryomodule test benches for AMTF
- Power supplies for Utilities
- **Transverse Deflecting Structures**







Spanish / Swedish / Suisse In-kind Contributions



MINISTERIO DE EDUCACIÓN Y CIENCIA
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

- **Superconducting magnets**
- Power supplies

UPPSALA UNIVERSITET

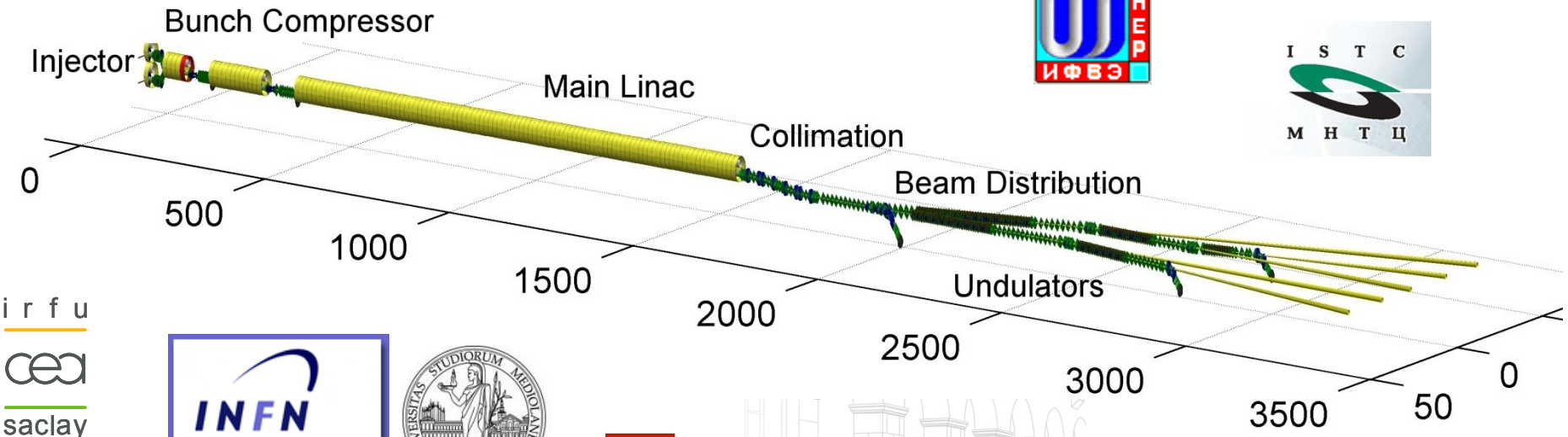
- **Laser heater** system for injector
- **Timing & synchronization** system + configuration management

PAUL SCHERRER INSTITUT PSI

- **BPM electronics**
- **Intra-bunch-train Feedback** System IBFB

European XFEL

Many Contributions to the Accelerator Complex



Wrocław University of Technology

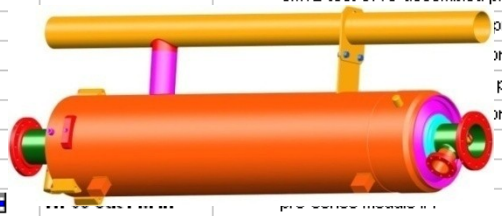
Institute of High Energy Physics
Chinese Academy of Sciences

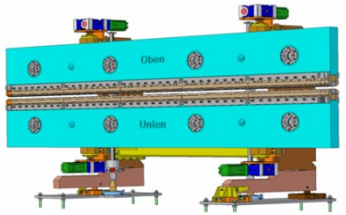
European XFEL

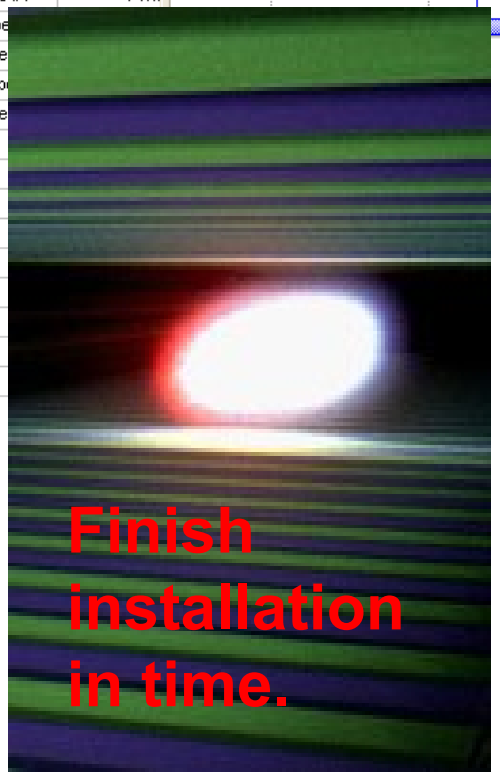
With One Common Goal:

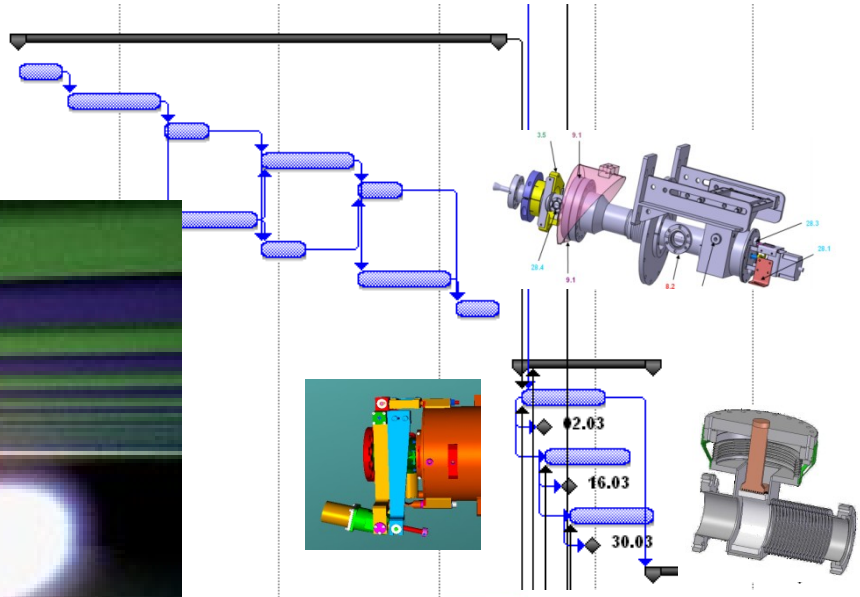
Gantt Chart

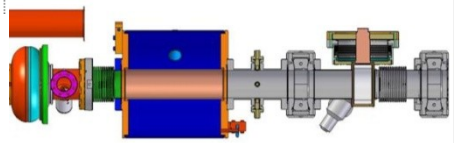
34	WP3/9 out PM in	string and module assembly training	200 dy
35		initial training of new assembly teams	4 wk
36		1st dis- and re-assembly of prototype modu	8 wk
37		CMTB test of re-assembled prototype #1	4 wk
38		2nd dis- and re-assembly of prototype modi	8 wk
39		CMTB test of re-assembled prototype #1	4 wk
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	





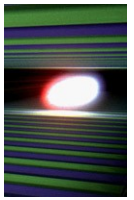






- So far “in time” has been “in 2014”.
- We are currently crossing the end of the year… can we avoid this?

DESY HELMHOLTZ ASSOCIATION



The end