The European XFEL

Status & Summary of SRF Activities

Hans Weise / DESY

a common project of many SRF experts

sharing the responsibility for the superconducting linac

Thanks to

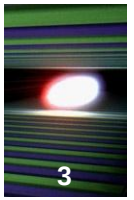
Aboud Falou / LAL

Olivier Napoly / CEA

as well as to all other work package leaders and co-leaders

further XFEL details in the WG contributions given by
S. Aderhold, L. Lukovac, W.-D. Moeller, J. Sekutowicz

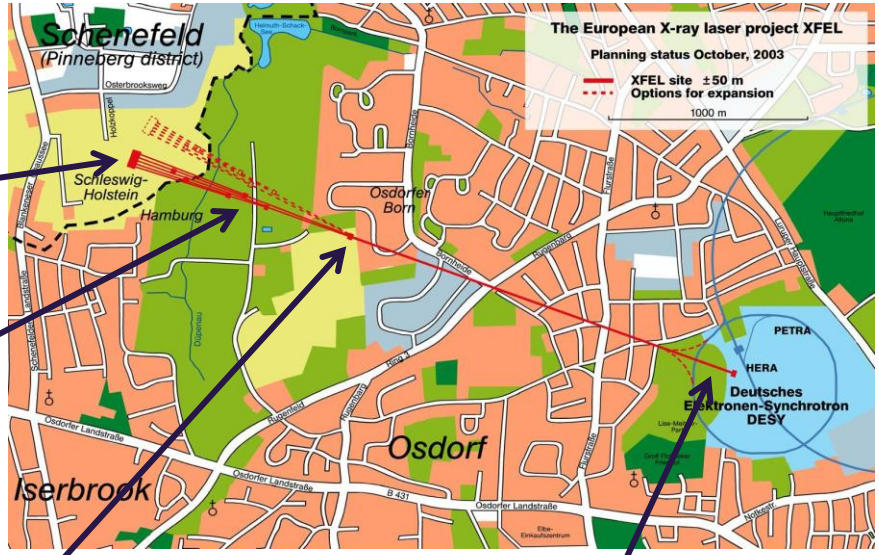
Content



- Civil Construction
- New XFEL Infrastructure
- Cavities
- Coupler
- Accelerator Modules
- Plans / Schedule

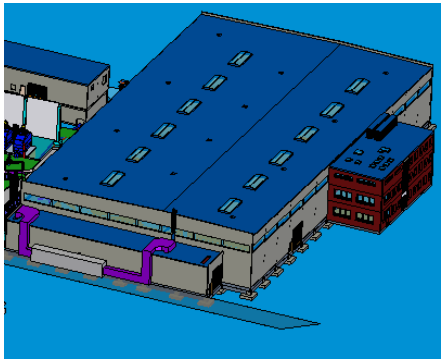
Civil Construction for the European XFEL

3.4km

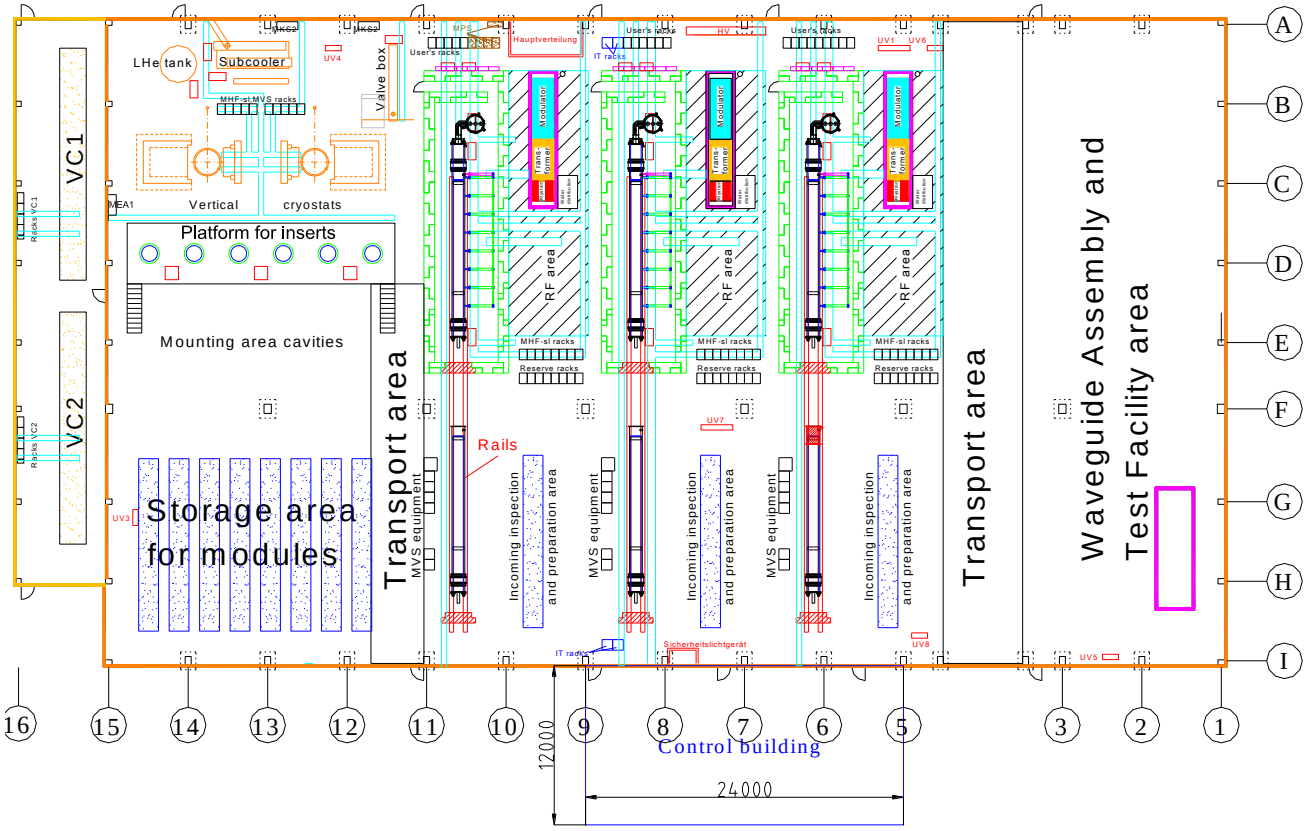


Civil Construction Accelerator Module Test Facility

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



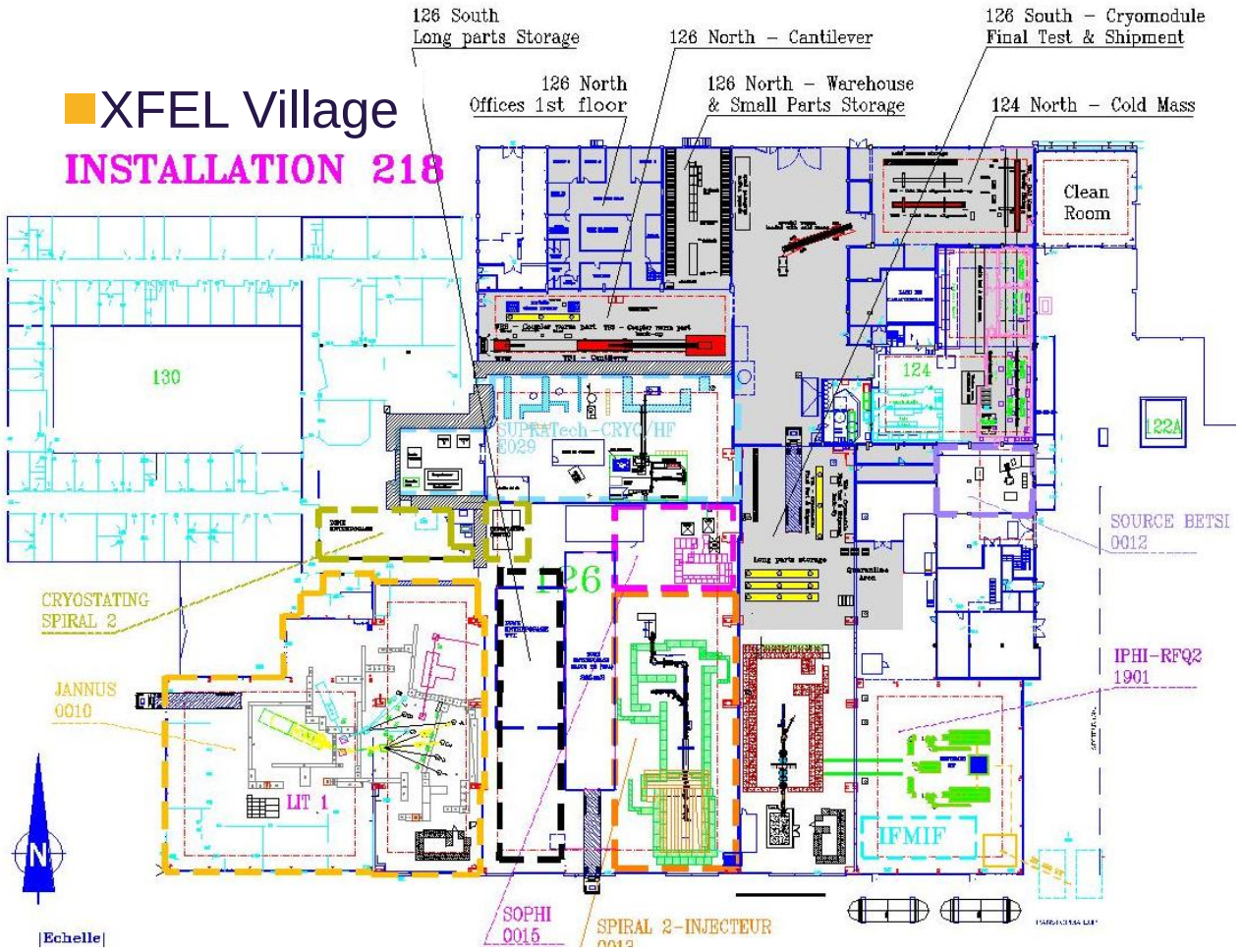
Accelerator Module Test Facility (AMTF) Including Single Cavity Tests



- Warm cryogenic piping 10/2010
- ISO- and UH Vacuum equipment 10/2010
- Vacuum compressors commissioning 11/2010
- cryo components (LHe sub cooler & He storage tank main transfer line & vertical cryostats) **are late** – fall 2011

- **Commissioning**
  - **- vertical tests late fall 2011**
  - **- horizontal tests end 2011**

Infrastructure for String & Module Assembly



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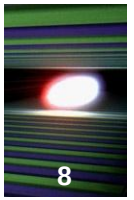
- Civil engineering and general equipments almost done; big assembly tools ordered and (to be) delivered.

String and Module Assembly - Workstations



- **Clean Room Cold Coupler Area** **(IS04-CC-WS1)**
  - – Cold coupler assembly
- **Clean Room String Assembly Area** **(ISO4-SA-WS1, ISO4-SA-WS2)**
- **Roll-out Area** **(RO-WS1, RO-WS2)**
  - – HOM adjustment, magnetic shielding, tuners,…
  - – 2PH-tube welding, cold-mass/string connection
- **Alignment Area** **(AL-WS1, AL-WS2)**
  - –Cavity and quadrupole fine alignment
  - – Coupler shields and braids, tuner electric tests
- **Cantilever Area** **(CA-WS1)**
  - – Welding of 4K and 70 K shields, super insulation
  - – Insertion into vacuum vessel and string alignment
- **Coupler Area** **(CO-WS1, CO-WS2)**
  - – Warm couplers + coupler pumping line
  - – Quad current leads
- **Shipment Area** **(SH-WS1, SH-WS2)**
  - – Instrumentation
  - – Control operations (electrical, RF), “acceptance test”
  - – End-caps closing, N-insulation, loading.

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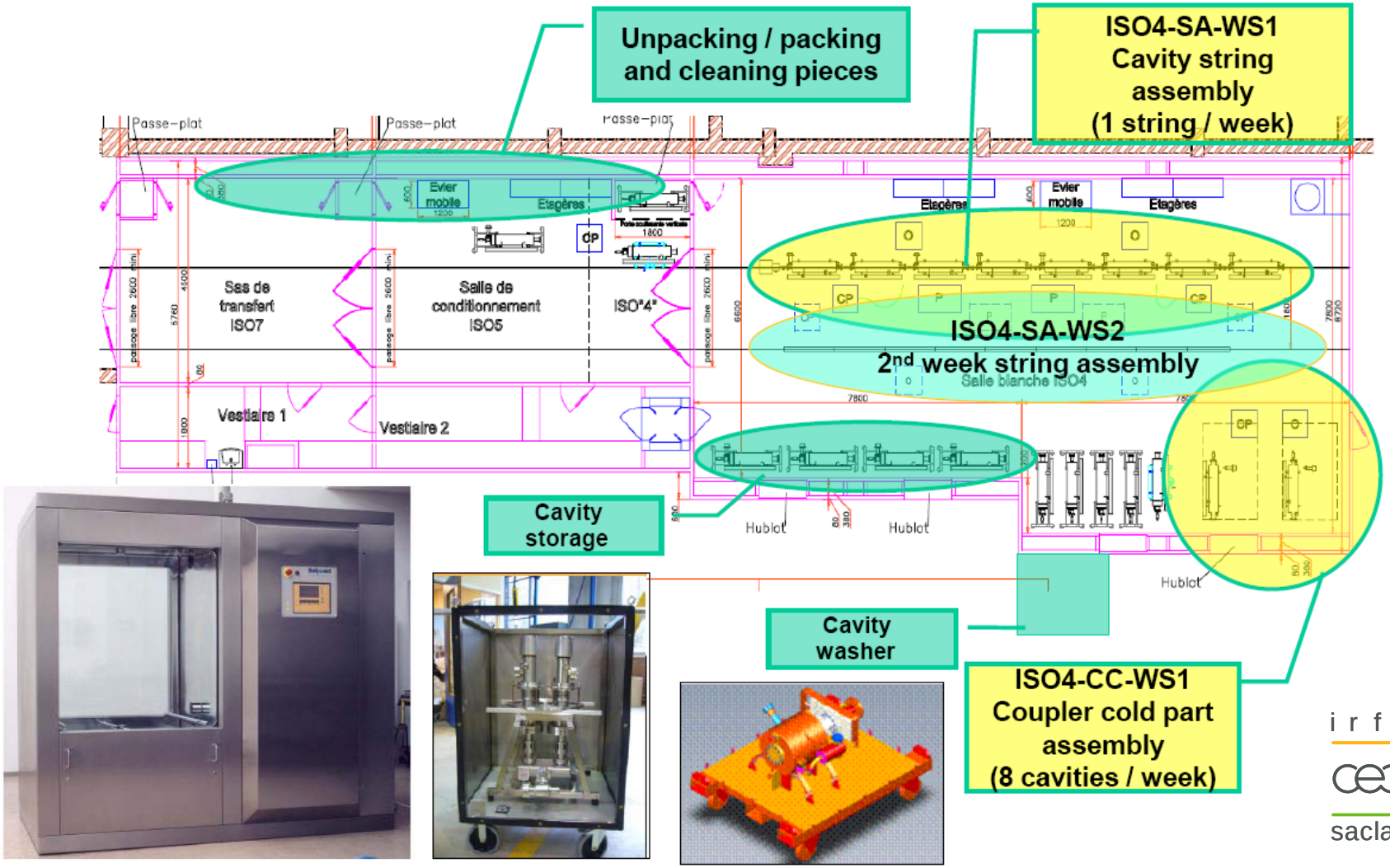
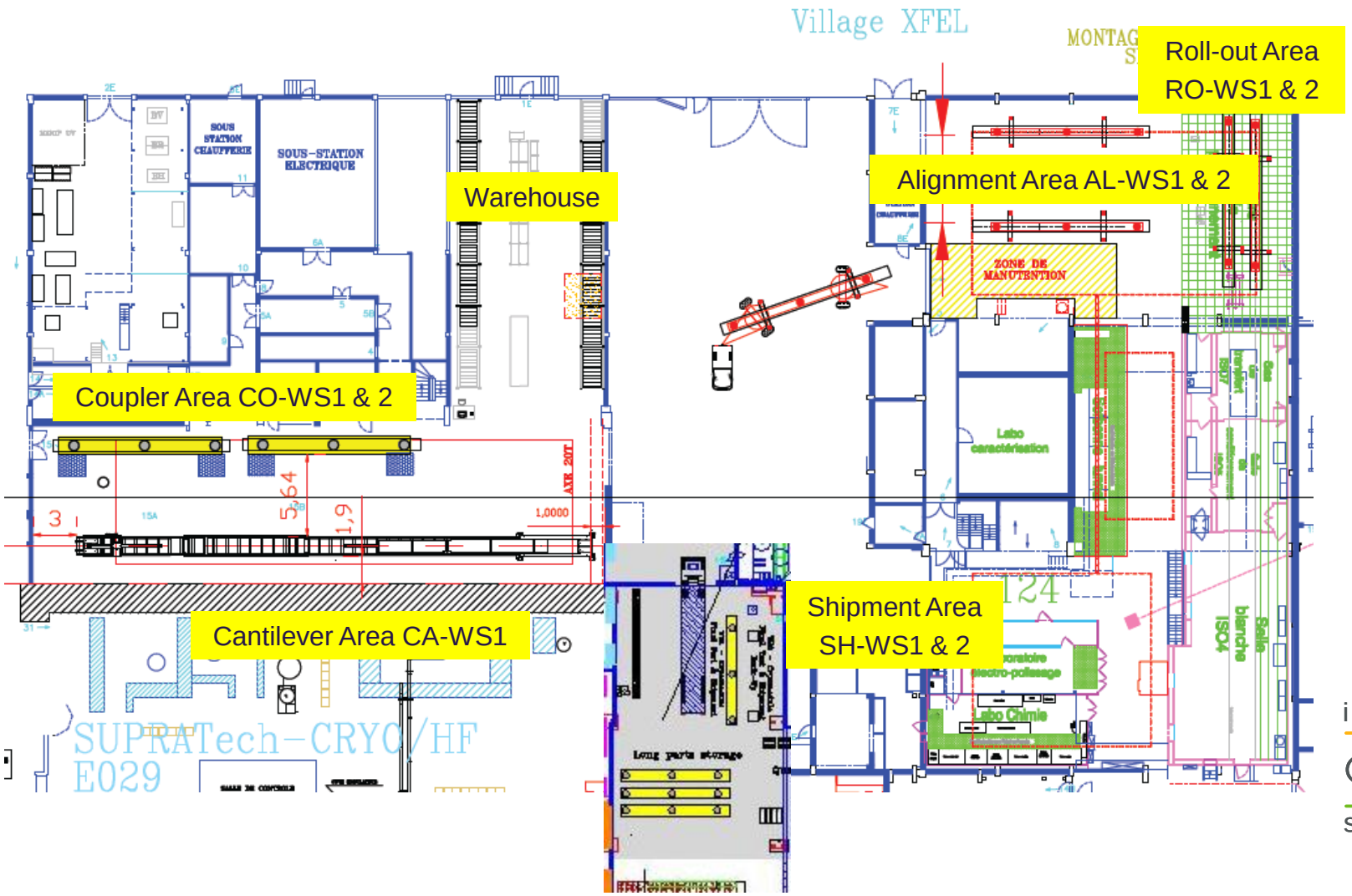
String Assembly - Workstations



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

Module Assembly - Workstations



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Infrastructure for Module Assembly

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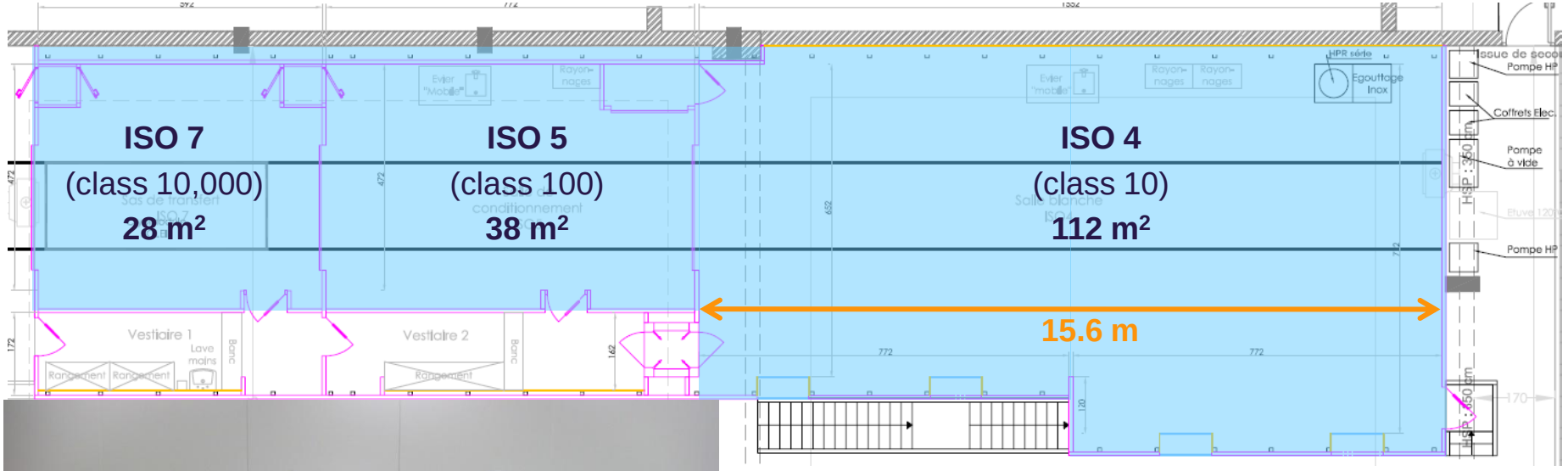
Infrastructure for Module Assembly



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Assembly Halls at CE Saclay

- Three Assembly Halls and Services (offices, dressing rooms, warehouse, central courtyard, etc…) are currently 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

- Two independent air systems
- Improved energy balance

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

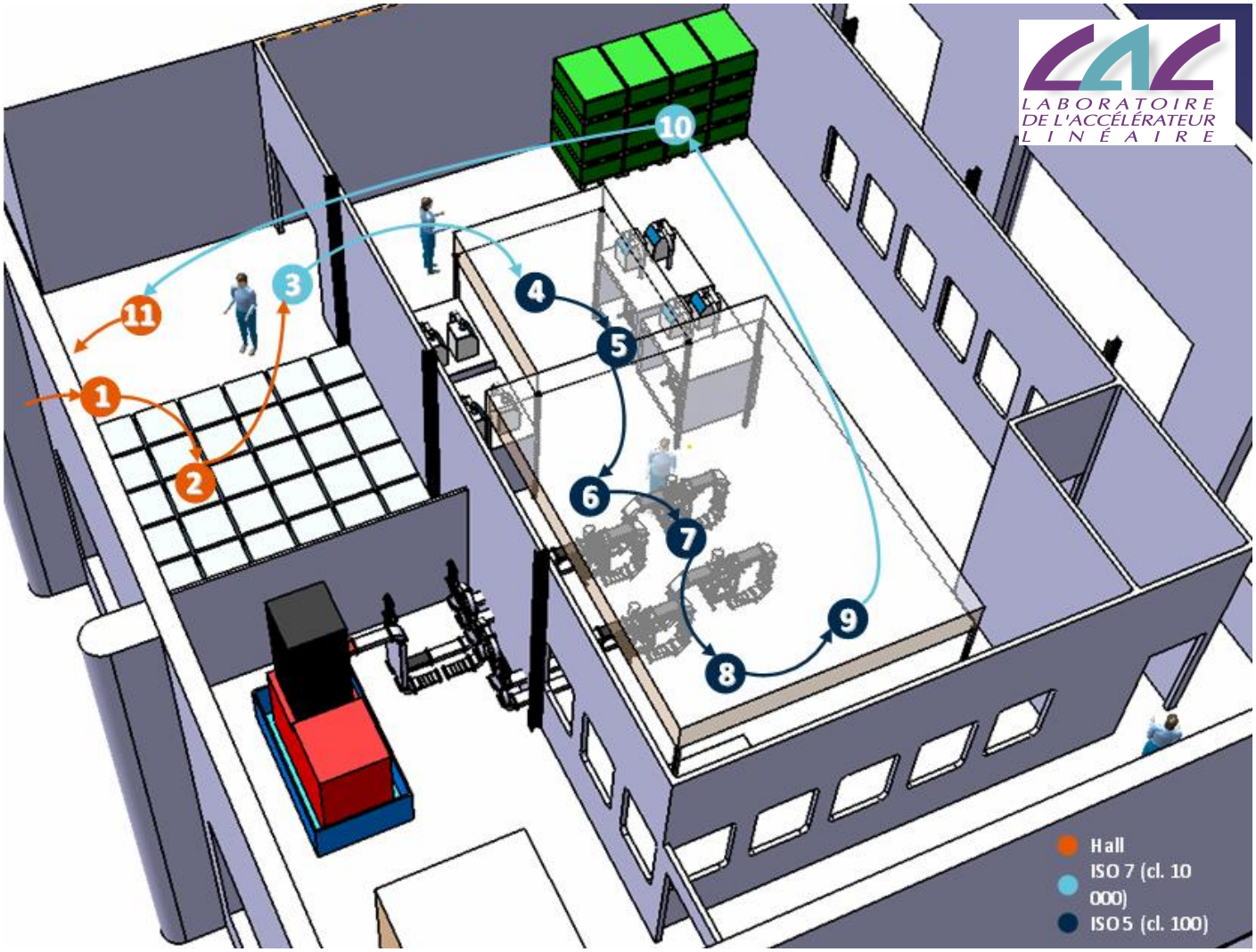
XFEL RF Power Coupler

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

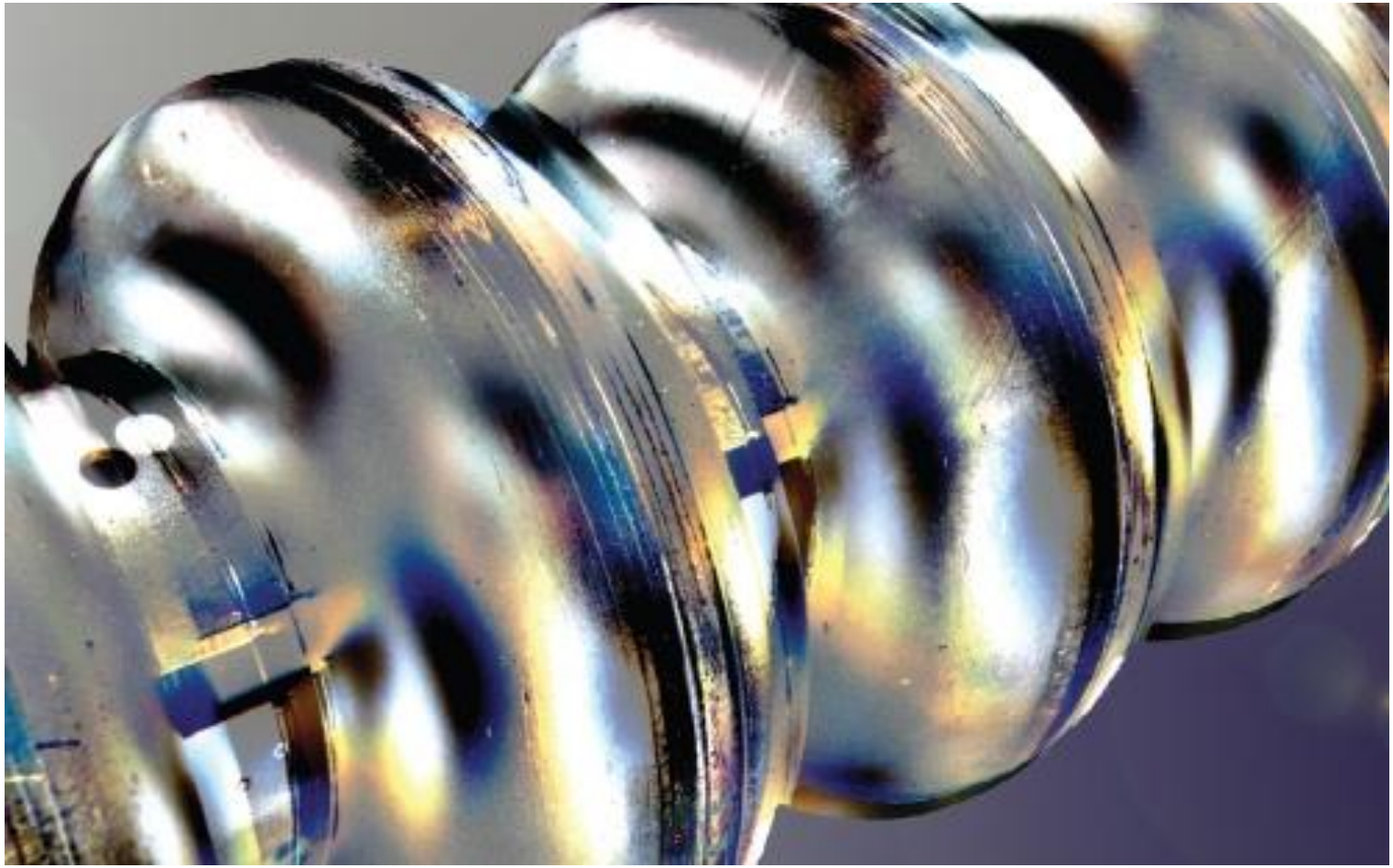
- Max. RF Power of **5 MW**.
- Conditioning rate of **8 couplers per week**.
- Either pairs (4 x 2 couplers) or units of 4 couplers (under study).
- Schedule is integrated in overall project schedule; depending on companies' cavity schedule… **very tight with no contingency!**
- Direct delivery to assembly site at CE Saclay.

RF Conditioning at LAL Orsay

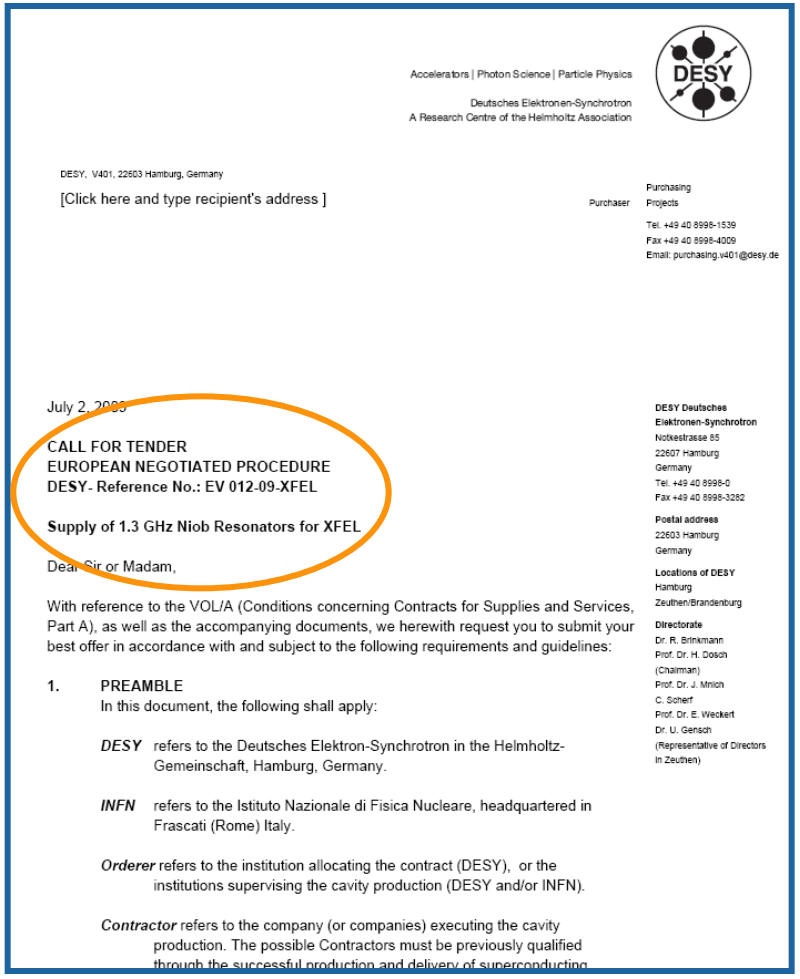
1. Reception
2. Storage
3. Unpacking
4. Leak check
5. In situ baking
6. S parameters
7. Conditioning
8. Dismounting
9. Packaging
10. Storage
11. Expedition



Cavities



Cavities – Call for Tender



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
Germany
Tel. +49 40 8998-0
Fax +49 40 8998-3282

Postal address
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)

- After the PRR (reported during last MAC), 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.
- Offers received end of November
- **Negotiations led to a second CFT…**

Cavities – Conclusions from the CFT

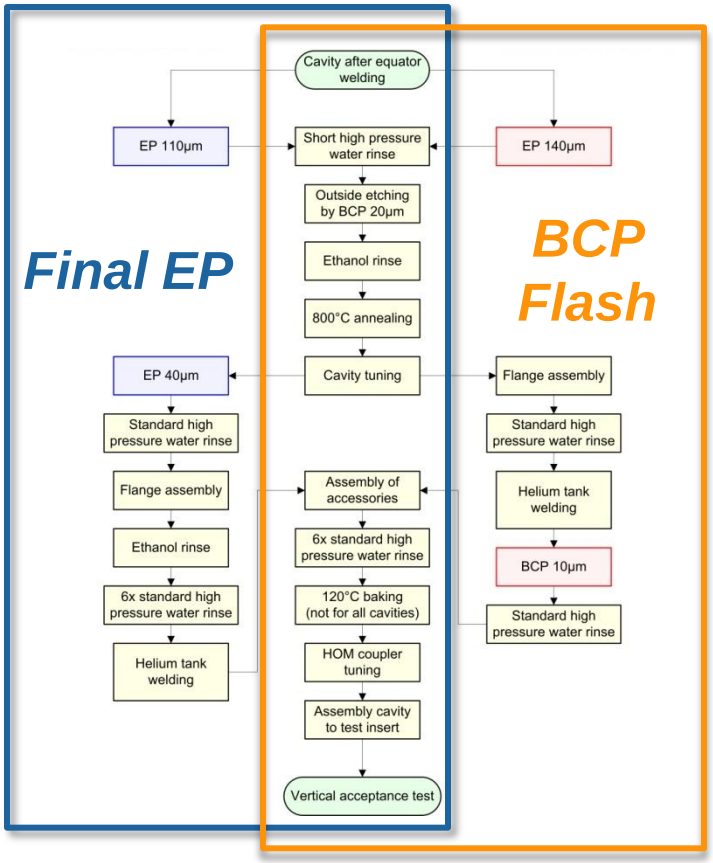
- **… second CFT with modified constraints …**
  - no performance guarantee
  - Nb and NbTi and/or He-vessel procurement possibly by the orderer

- **Results:**
  - reasonable offers received
  - understanding of increased costs, cost breakdown, risks & margin
  - decision possible
  - intention to place contracts a.s.a.p.
  - series cavities to be delivered in 2012 & 2013
  - total number of cavities / couplers / modules reduced to 80%
  - consequences for the orderer (DESY) were carefully studied (add. effort, schedule, resources, …)

From the 1st XFEL MAC: With realistic assumptions on lower beam emittance, linac energy reduction by 20% to 14 GeV appears as a reasonable compromise between cost aspects and scientific potential of the facility. CW mode remains an interesting future option, but: If CW mode is realized, this should go along with re-establishing the full (TDR) linac length to permit ~7GeV.

Cavities

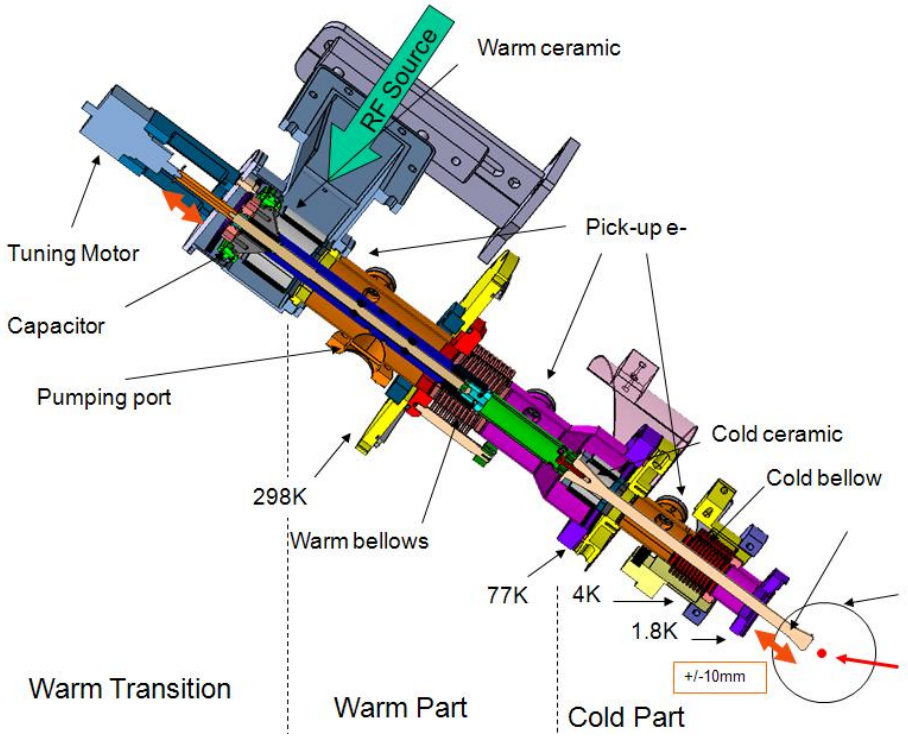
- **Two schemes** for the final surface treatment (***Final EP*** and ***BCP Flash***) were studied with **cavities from two different vendors**.
- The **preparation strategy** to go for a final treatment with the cavity already welded into the He-vessel was investigated.



- **Results** are:
  - yield curves for the different schemes
  - yield curves for the different vendors
  - a preparation strategy allowing two different end preparations
  - a strategy for the call for tender in terms of gradient, batch size, option
- Some **tooling** will come from DESY
- **DESY procedures and experience** described very much in detail in the CFT; publication unfortunately not earlier than 6 months after contract placing

XFEL RF Power Coupler

- *TTF3 coupler type*

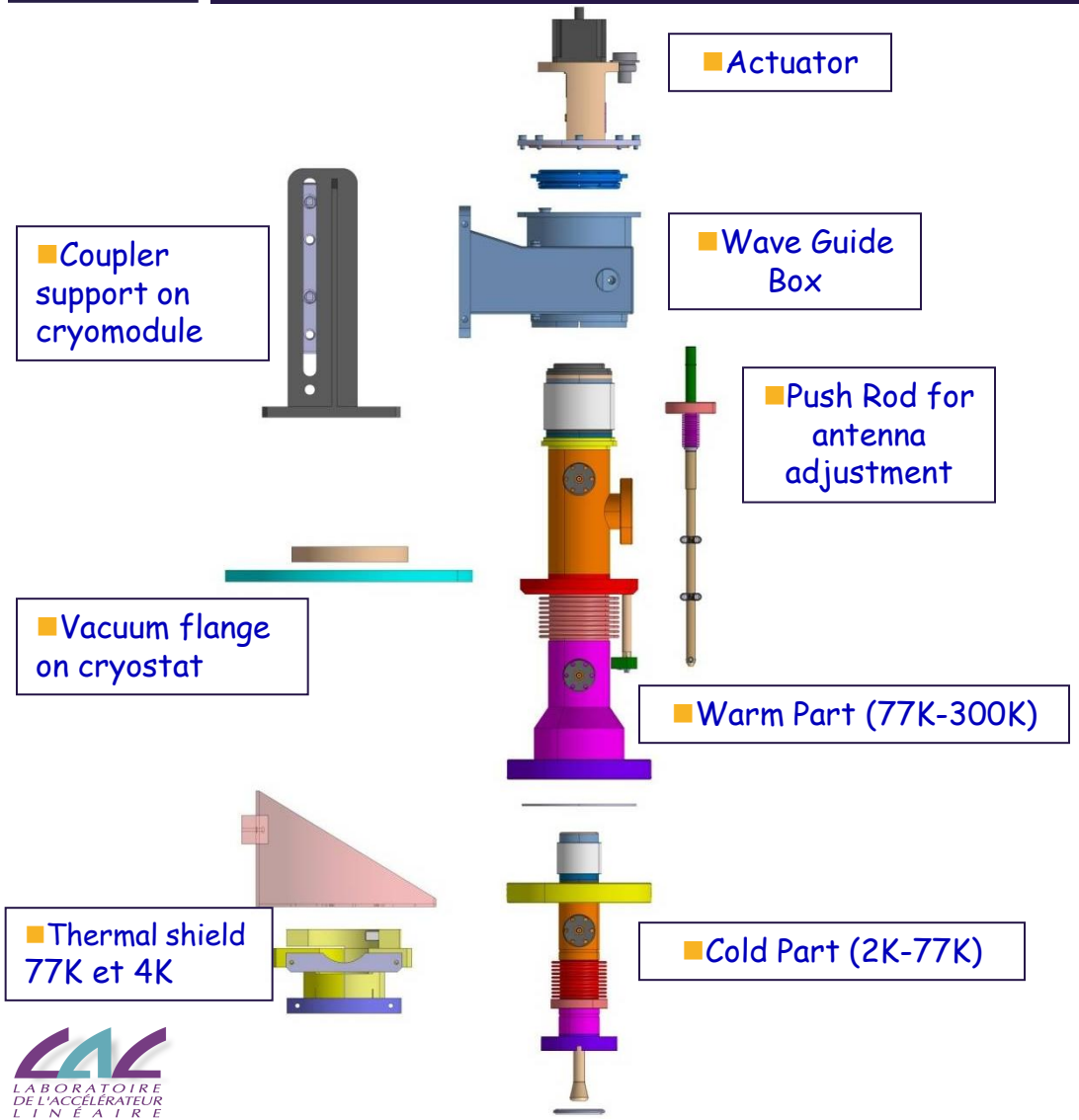


- **LAL Orsay** has taken over the responsibility for the XFEL RF power **coupler production**.
- **Conditioning** of the couplers will take place at LAL Orsay.
- The **coupler interlock** system was developed and will be **contributed by DESY.**
- An open **Call for Tender** was **published** two weeks ago. Based on all the detailed work at LAL and DESY, discussions of a Coupler Expert Committee established by LAL, and a Production Readiness Review.

XFEL-WP05_DCE_CORPUSUS
CCTP Corpus/ coupler characteristics

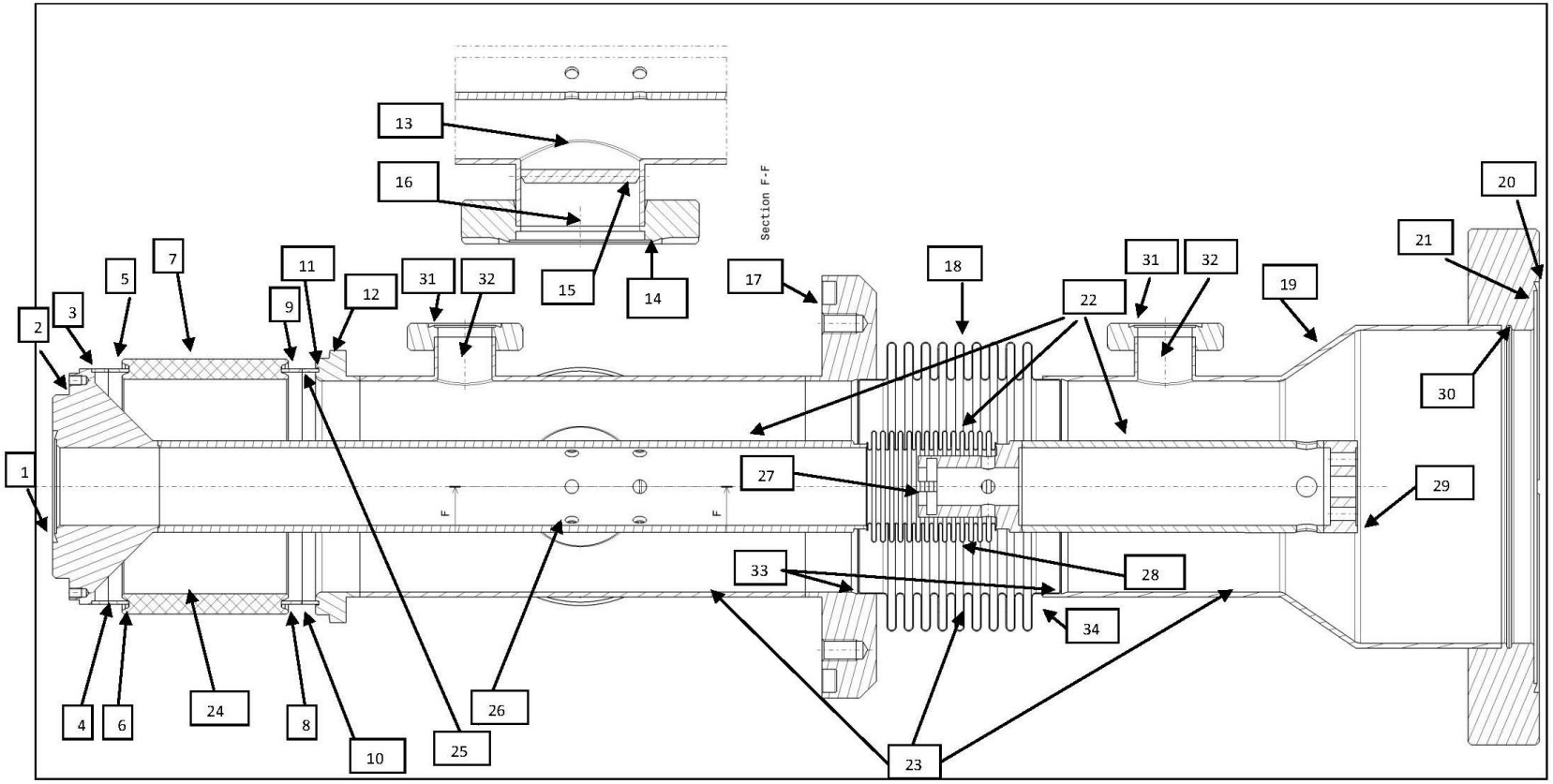
Frequency	1.3 GHz
Operation	Pulsed: 720 µsec filling time, 600 µsec at 5mA beam
Peak power + control margin (27%)	≤ 150 kW (for a cavity gradient of 23.6 MV/m)
Repetition rate	10 Hz
Coupling (Qext)	$2x10^6$ / $2x10^7$
Two ceramic windows	Safe operation/ clean cavity assembly for high gradient
Maximum heat losses	0.06W at 2K/ 0.5W at 4K/ 6W at 70K
Insolated inner conductor	Bias voltage, suppressing multipacting
Cavity position during cool down	Fixed point (1.5mm longitudinal shrinkage)
Diagnostic	Sufficient for safe operation & monitoring

XFEL-WP05_DCE_ANX_09
Coupler Parts & Manufacturing Sequence



- Material Specification & Procurement
- Heat treatments, Forming, machining
- Degreasing, 1st cleaning
- Parts Welding, Brazing
- Thin layers coating (Copper & TiN)
- Final welding Assemblies
- Dimensions & roughness measurements
- Final cleaning, drying, Particle counting
- Visual inspection of all RF surfaces
- Coupler complete assembly on RF stand
- (He Leak checks + RGA, actuator running)
- Coupler pair packing & transport to LAL
- Cold Part vacuum, Warm Part under N2

XFEL-WP05_DCE_ANX_07
List of Inspections & Controls/ Visual Inspection



XFEL-WP05_DCE_ANX_07
List of Inspections & Controls/ Visual Inspection

Spot	Description of the spot to be visual inspected	Rejection criteria
1	Knife edge	Sharp edges, scratches
2	Contact surface with the capacitor, fixation	Sharp edges, scratches
3	Brazing joint : regularity, smoothness, centering	Lack or excess of filler metal
4	Welding joint : regularity, smoothness, centering	According to the specific criteria
5	Cu rings : centering, shape, smoothness	According to the specific criteria
6	Ceramic brazed : regularity, smoothness, centering, metallization	Lack or excess of filler metal Excess of metallization
7	Ceramic and TiN coating : color, stains, no chips, no particles	Projections, discoloration
8	Ceramic brazed : regularity, smoothness, centering, metallization	Lack or excess of filler metal Excess of metallization
9	Cu ring : centering, shape, smoothness	According to the specific criteria
10	Welding joint : regularity, smoothness, centering	According to the specific criteria
11	Brazing joint : regularity, smoothness, centering	Lack or excess of filler metal
12	RF contact surface with the WGB	Sharp edges, scratches
13	Pumping port : radius, regularity, smoothness	Sharp edges, right angles
14	Knife edge _ orientation of holes	Scratches _ see details
15	Rounded inner edges	Sharp edges
	Orientation of the port	According to the tolerance range

XFEL RF Couplers/ from R&D to Mass Production

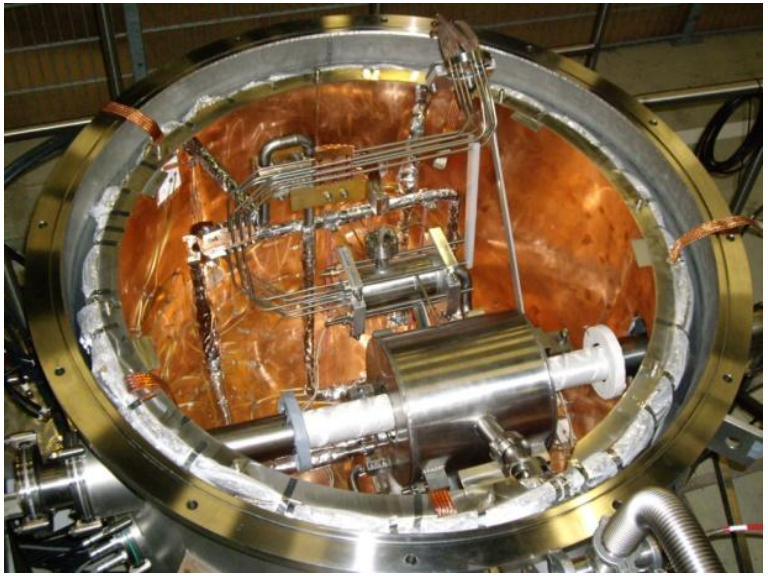
Planning 2009-2013

Item	description	Ressource	Deadline
1.1	CCTP/CCAP redaction, Lecture, comments, corrections	Technical Team + LAL SG	Mars 2009 W52 2009
1.2	French→ English Translation of full DCE (2 stages; technical & legal matters except market rules)		W48-W04 2010
1.3	**Revue de Projet Interne IN2P3 (LAL-Orsay)**	**T.T + Reviewers**	**06-07-2009**
1.4	CCTP (English) submission to CEC & PRR reviewers including drawings folders/ Lecture, comments, corrections	CEC + PRR reviewers	W48-W52
1.5	**CEC Review (technical +project organization) & PRR session/ 2 days at LAL-Orsay**	**T.T + CEC + Reviewers**	**12-13 Jan 2010**
1.6	Submission to PRR & CEC reviewers of full Call for Tender dossier including previous corrections & recommendations	T.T + LAL SG + DDA (CNRS)	W02 2010
1.7	**Approval of Call for Tender dossier by PRR reviewers**	**PRR Reviewers**	**14-15 Jan 2010**
2.1	**Administrative Approval of DCE & publication**	**DDA-CNRS**	**12/04/2010**
2.2	Offers deadline to be submitted to DDA-CNRS	Candidates	27/05/2010
2.3	Offers analysis, audits, firm selection (single contract)	ET + DESY	W16/ 2010
2.4	**Contrat Review/ Notification**	**DDA + contractor**	**W17/ 2010**
3.1	**24 Pre-series production {components, assembly, cleaning, packing & delivery to LAL-Orsay with QA traveller.**	**Contractor**	**Q03/2010 to Q2/2011**
3.2	**RF Conditioning of pre-series 24 units (correctives actions with contractor before ramp up)**	**LAL**	**Q03/2010 to Q02/2011**
3.3	Ramp up in production rate, 6x8 couplers {4 pairs/month /contractor}, total of 72 units end 2011 (9 cryo-modules)	Contractor + LAL + IRFU	From Q03 to Q04/2011
3.4	Monthly delivery of 2x16 couplers, total of 640+30 couplers 8 couplers/week over 18 months of regular rate	Contractor + LAL + IRFU	Q01-2012 to Q02-2013

- CCTP/CCAP starting
- IN2P3 Project Review (6th of July)
- CCTP/CCAP correction
- CEC/PRR (12-13-14 Jan)
- Call for Tender 12/04/2010
- Market Award 05/07/2010
- Pre-series {24 couplers) From July 2010 to June 2011
- Ramp up phase starting
- Regular Production phase
- Delivery of Last couplers (June)

2009 | 2010 | 2011 | 12 | 13

S.C. Magnets



- **2K-Magnets**
  - 3 magnet from CIEMAT delivered in 2008-2009
  - Successfully tested at XMTS
  - Field quality, strength and iron saturation is as required
  - ***Persistent current effects appear to be large***
- **Magnet redesign done in 2009**
  - decrease production costs
  - use available materials
    - → very difficult to get steel for low temperatures and pressure vessel conditions
  - use better superconducting wires to reduce persistent current effects
    - → with much smaller filament size
    - → and to get better performance at low fields
  - ***Difficulties to find proper materials***
- **Next magnet**
  - coil production at CIEMAT done
  - Magnet vessel in preparation in industry
  - Delievery now expected soon; ***extensive cold test at XMTS (DESY)***

S.C. Magnets / Current leads

Current leads

- Received 3 sets of current leads in 2009
- ***All tested at XMTS***
- electrical performance up ok to 60A (50A nominal)
- ***But heat load to 2K are larger than expected (discovered in CMTB)***
  - contributions of the leads to the total loads not separable on XMTS
  - measurements at CMTB indicate larger effects than at XMTS
- ***Redesign done***
  - now closer to the first version for the older modules (M8), which was ok at CMTB
  - Improved heat sink design
  - 3 leads ordered, first set installed in PXFEL3, the others to be extensively tested at XMTS
- ***Detailed tests on the operation safety done*** recently
  - Leads con be operated up to 60A without the low T heat sink up to 60A
  - At 60mbar (no super-fluid Helium) the connection to the magnet and parts of the magnet get normal conduction and after “long” time trigger the power supply switch off
  - Safe operation!

European XFEL

PXFEL Modules

PXFEL1 ready for FLASH

PXFEL3 ready for module assembly

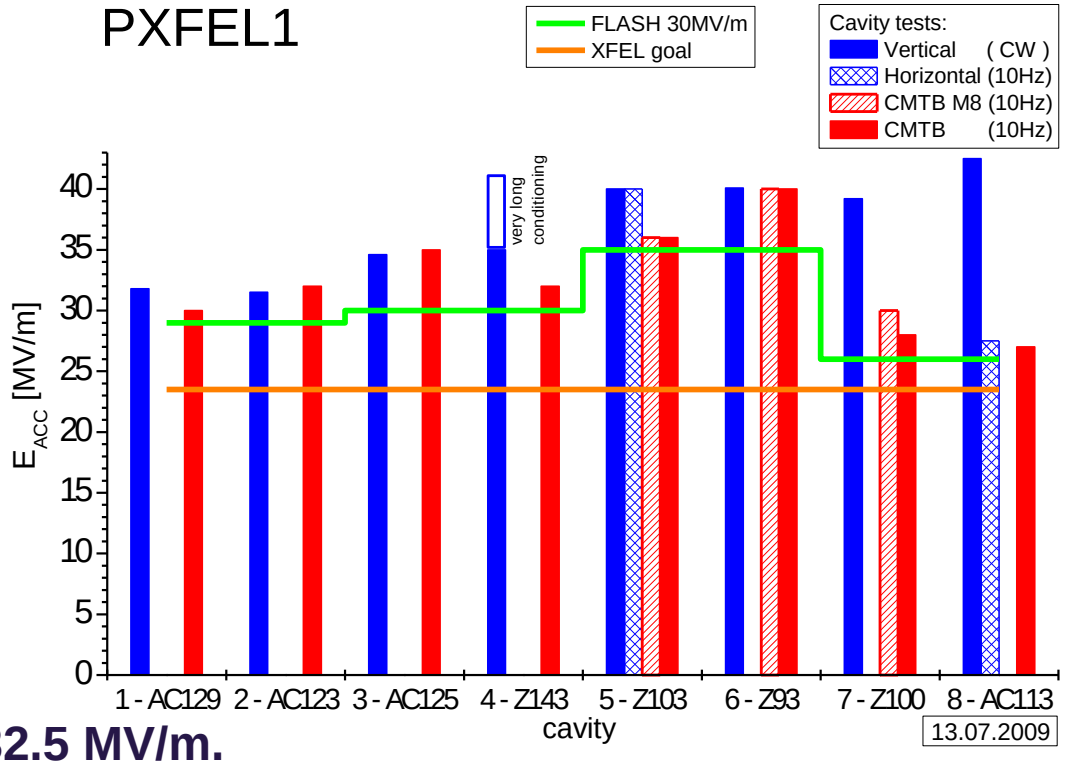
PXFEL2 ready for transport test DESY – Saclay – DESY

Detailed study

PXFEL3 string assembly & training

DESY HELMHOLTZ ASSOCIATION

PXFEL1 - The *Chinese* Module at CMTB



- 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 has been installed at FLASH and **can be operated** there with an average gradient of **30 MV/m.**
- The **XFEL waveguide distribution** is used.

European XFEL

PXFEL1 being part of FLASH's 4-module string

DESY HELMHOLTZ ASSOCIATION

European XFEL

Module Storage

Final Remarks

- We see quite some success in the field of Cold Linac **BUT…**

  there is no contingency for some of the long lead items.

- We are ready to order and are waiting for the go-ahead of the respective funding agencies.

- As soon as the final cavity production schedule is available we will check and perhaps adjust the overall schedule. The **cavities should be the dominating component** in the overall cold linac schedule. According to the actual status:

Infrastructure	ok
Cold mass & vacuum vessel	ok (CFT early summer)
Coupler	ok
HOM / tuner / magnets / vacuum	ok
AMTF hall	ok
AMTF installation	ok (no contingency)

- At present we assume module installation and linac cool-down in 2014.

The end