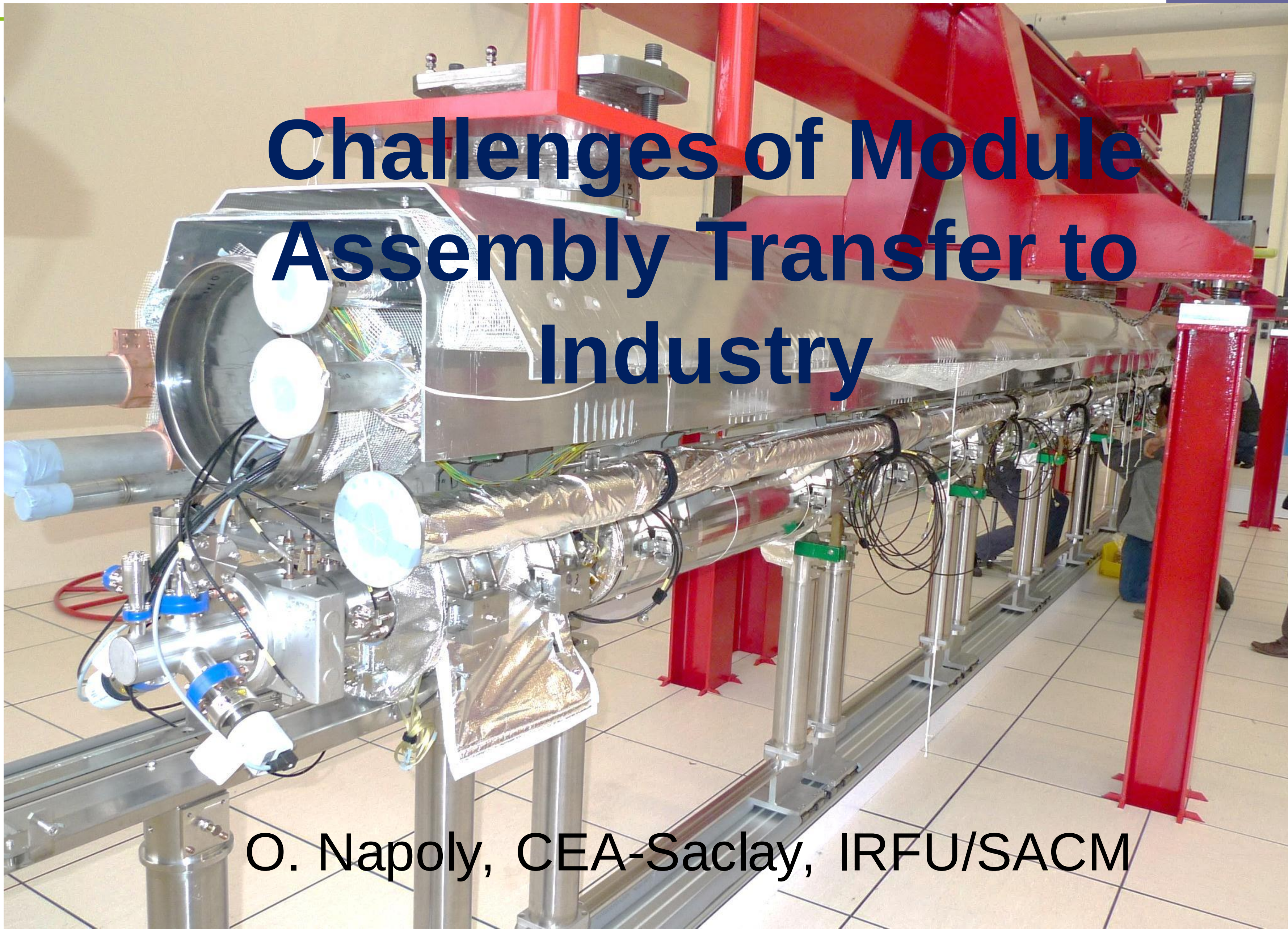
Challenges of Module Assembly Transfer to Industry



O. Napoly, CEA-Saclay, IRFU/SACM

Outline

- Baseline Scenario
  - Goals
  - Phasing of Industrialization
- Preparation for Industrialisation
  - Input Data Readiness
  - Selection of Industrial Operator
- Implementation of Industrialisation
  - Management plan
  - Quality Plan
  - Industrialization Plan
- Particular Issues
  - ISO4 string assembly procedures
  - Plug Compatibility

Goal of this Enterprise

↓

Accelerator Module Assembly

assembly of 103 accelerator modules

with **1 per week throughput** !

operated by an **industrial contractor**

on the Saclay site and CEA infrastructures.

CEA Project Timeline

Our effort develops over the 3 phases:

Phase 1: **Preparation of Infrastructure and Tooling:**

2008 → mid-2010

Phase 2: **Training and Commissioning at Saclay** with XFEL Prototype Modules (PXFEL2 and PXFEL3):

August 2010 → August 2012

(PXFEL2_2 was shipped to DESY on Sept. 4, 2012)

leading to Restricted Call for Tender for Assembly Contract

in Aug. 2011: *contract signed in July 2012, T_0 = 20/08/2012*

Phase 3: **Industrial Production**

XFEL module assembly by industry operator

September 2012 → Qi 2015

Kick-off Meeting 5 September 2012

XFEL Village at Saclay

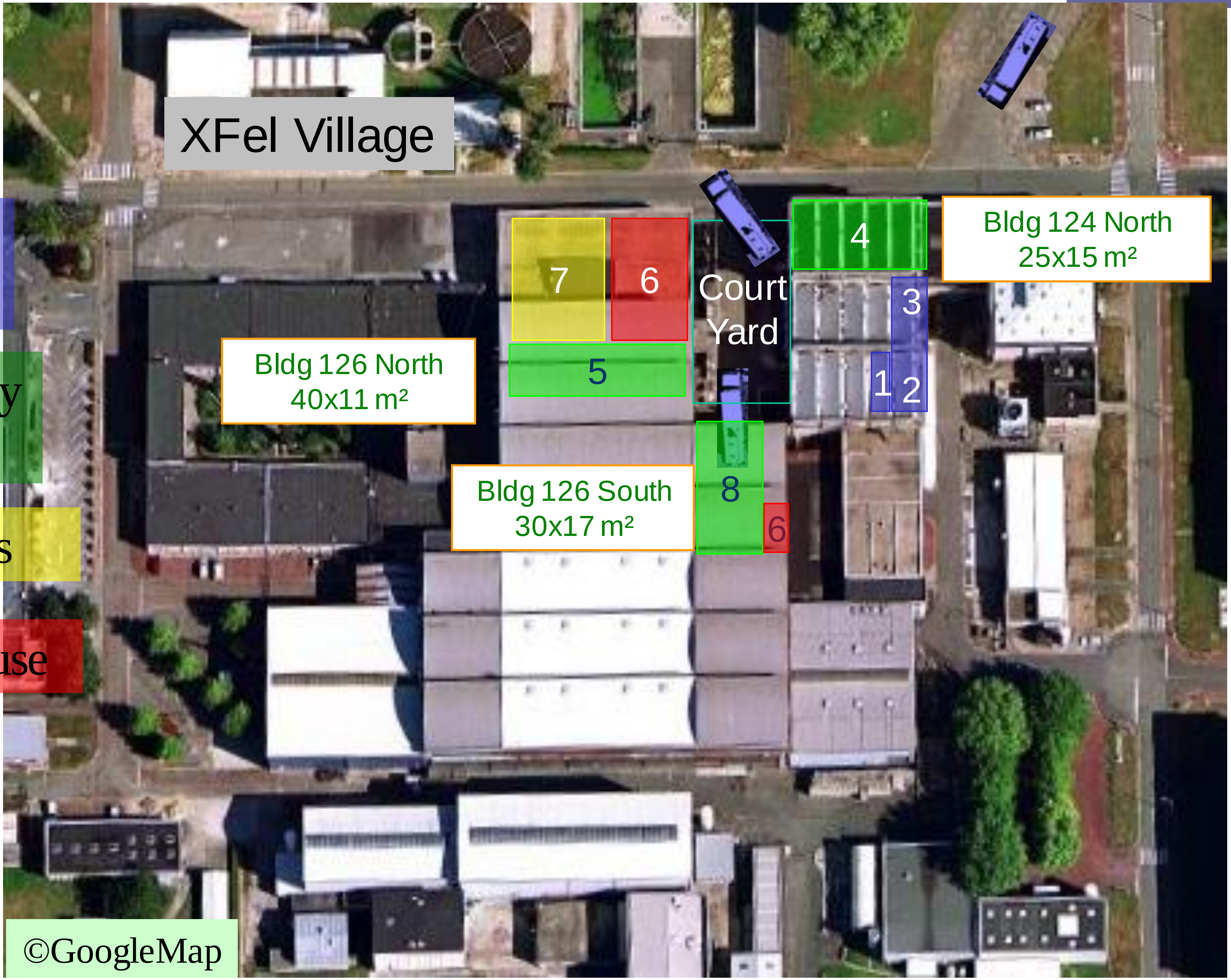
Overview of the Assembly Buildings

Clean rooms

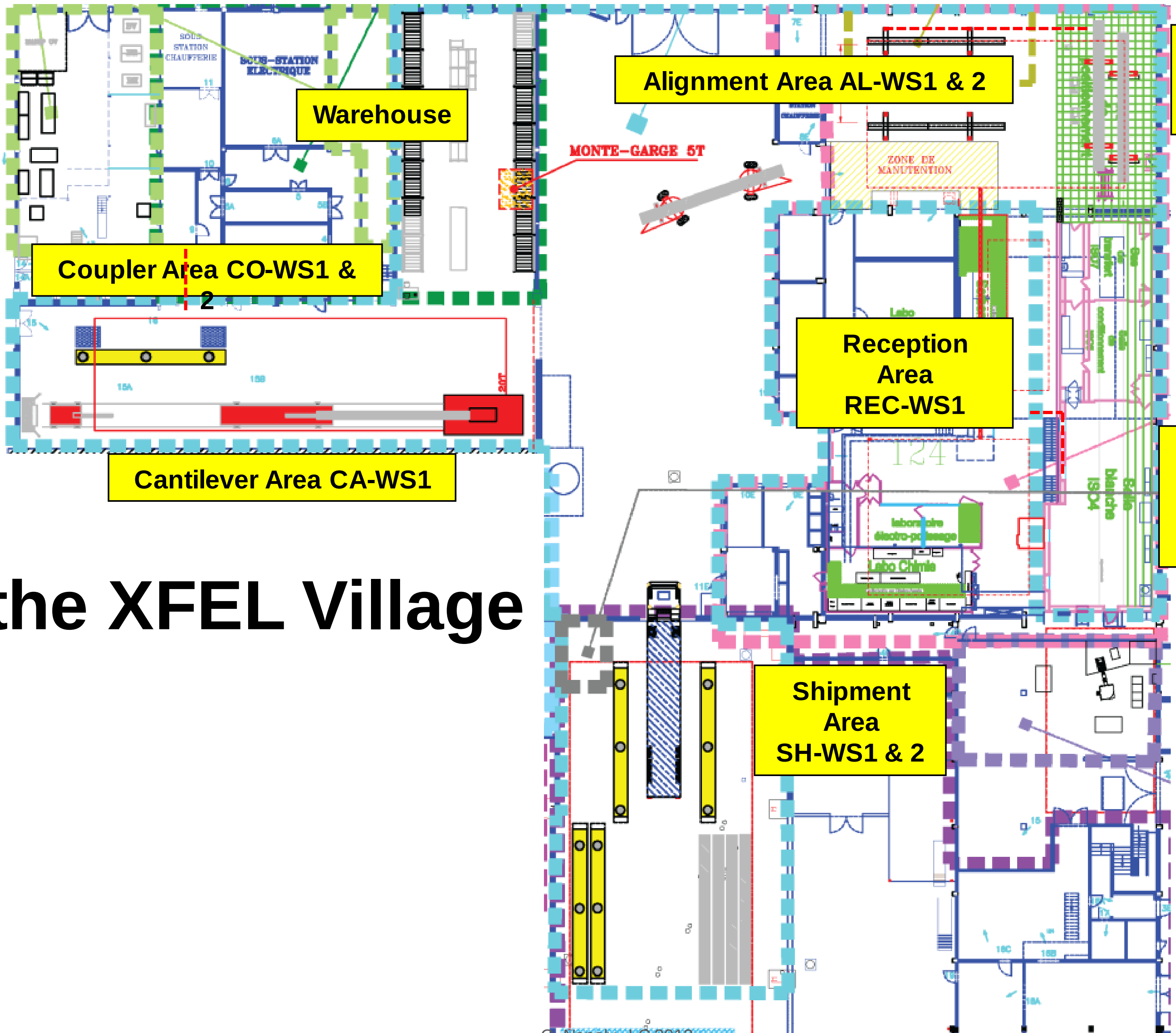
Assembly halls

Offices

Warehouse



Assembly Hall : Workstations



the XFEL Village

Organisation of Work Stations

1. **Clean Room Cold Coupler Area** (IS04-CC-WS1)
   – Cold coupler assembly
2. **Clean Room String Assembly Area** (ISO4-SA-WS1, ISO4-SA-WS2)
   – String connections (1 gate valve + 8 cavities + 1 Qpole unit)
3. **Roll-out Area** (RO-WS1, RO-WS2)
   – HOM tuning, magnetic shielding, tuners,…
   – 2Ph-tube welding, cold-mass connection
4. **Alignment Area** (AL-WS1, AL-WS2)
   – Cavity and quadrupole fine alignment
   – Coupler shields and braids, tuner electric tests
5. **Cantilever Area** (CA-WS1)
   – Welding of 4K and 70 K shields, super insulation
   – Quad current lead
   – Insertion into vacuum vessel and string alignment
6. **Coupler Area** (CO-WS1, CO-WS2)
   – Warm couplers + coupler pumping line
   – Control operations (electrical, RF)
7. **Shipment Area** (SH-WS1, SH-WS2)
   – CEA-Alsyom “acceptance test”
   – End-caps closing, N2-insulation, loading.

In full production, this chain of workstations will be fully occupied with 7 cryomodules (XM_{n-6} @ WS1,…, XM_n @ WS7) stationed for one week.

Cryomodule Factory !

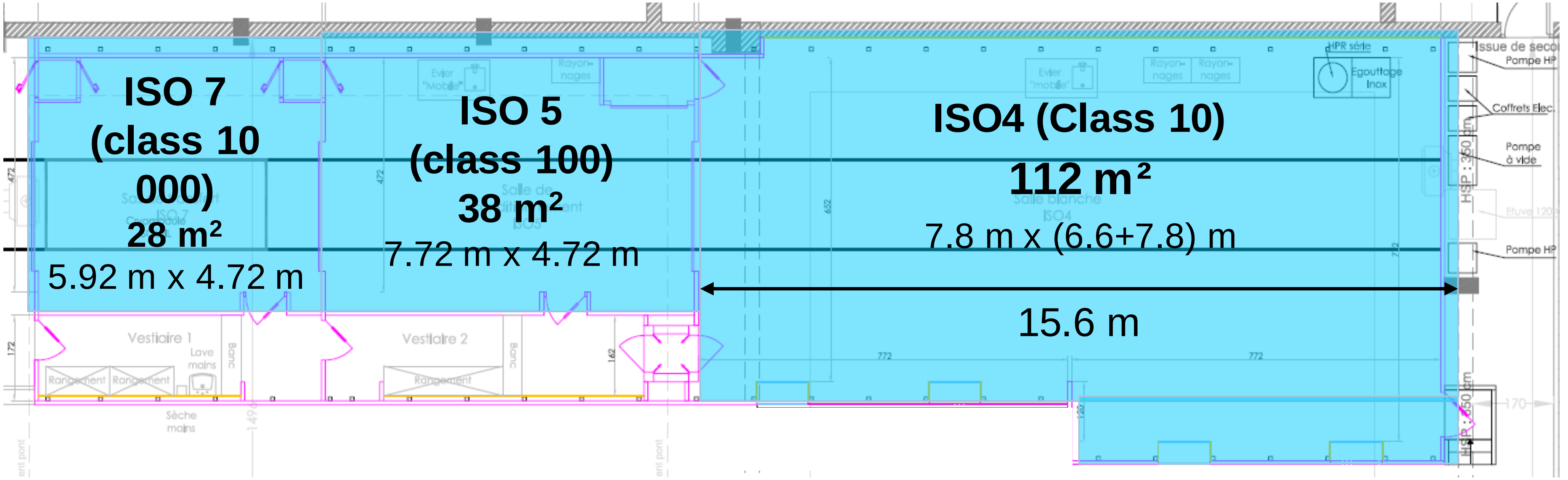
Assembly prototyping at Saclay

Cavity and Coupler Reception (ISO5-CR-WS1)

0.a Cavity and coupler reception

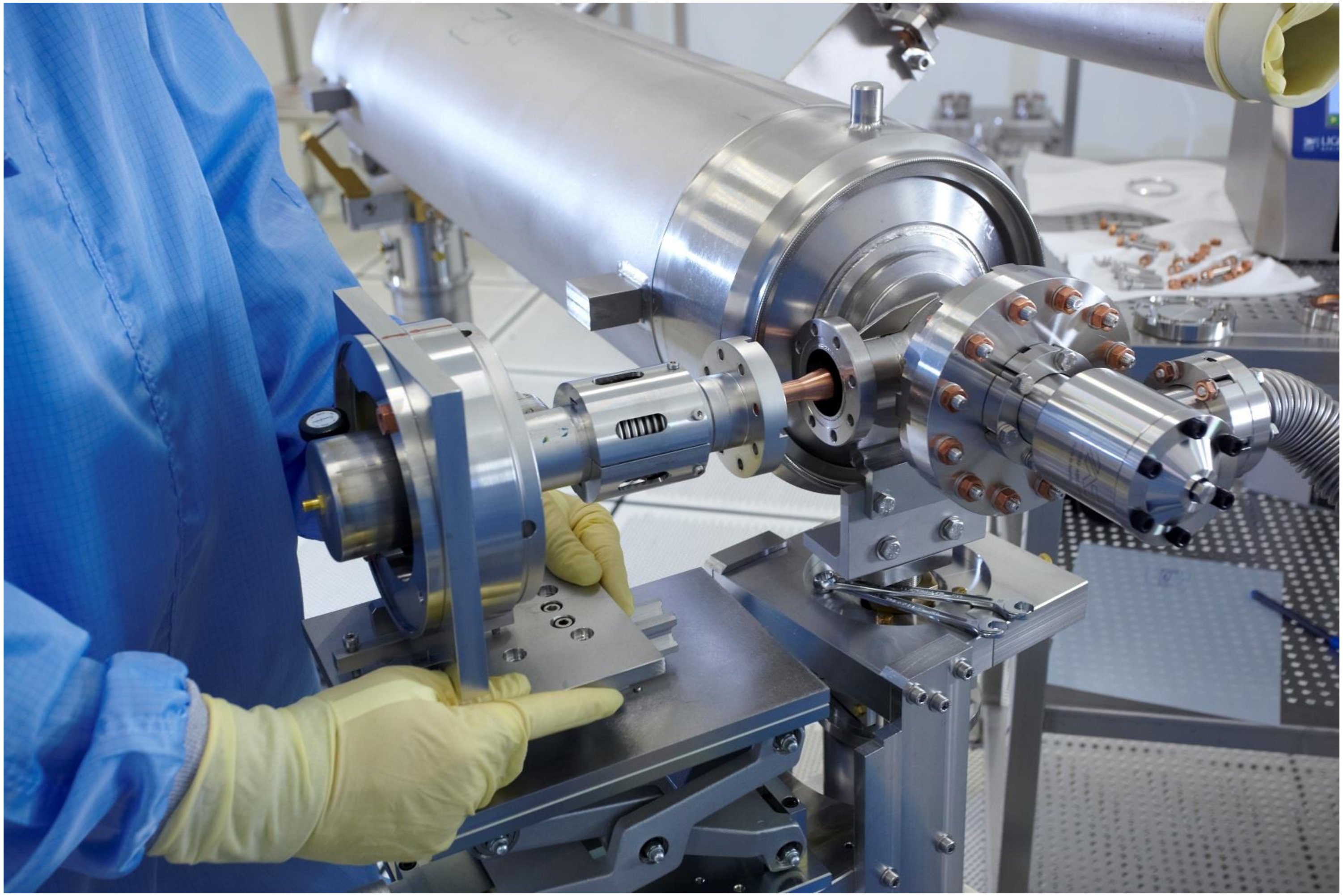
0.b Cavity and coupler washing

Clean Room Layout



Assembly prototyping at Saclay

1. Coupler Cold Part assembly (ISO4-CC-WS1&2)



Assembly prototyping at Saclay

2. Cavity String assembly (ISO4-SA-WS1&2)

Assembly prototyping at Saclay

3. String dressing on Roll-out station (RO-WS1&2)

Assembly prototyping at Saclay

4. Alignment (AL-WS1&2)

Cryomodule Transfer

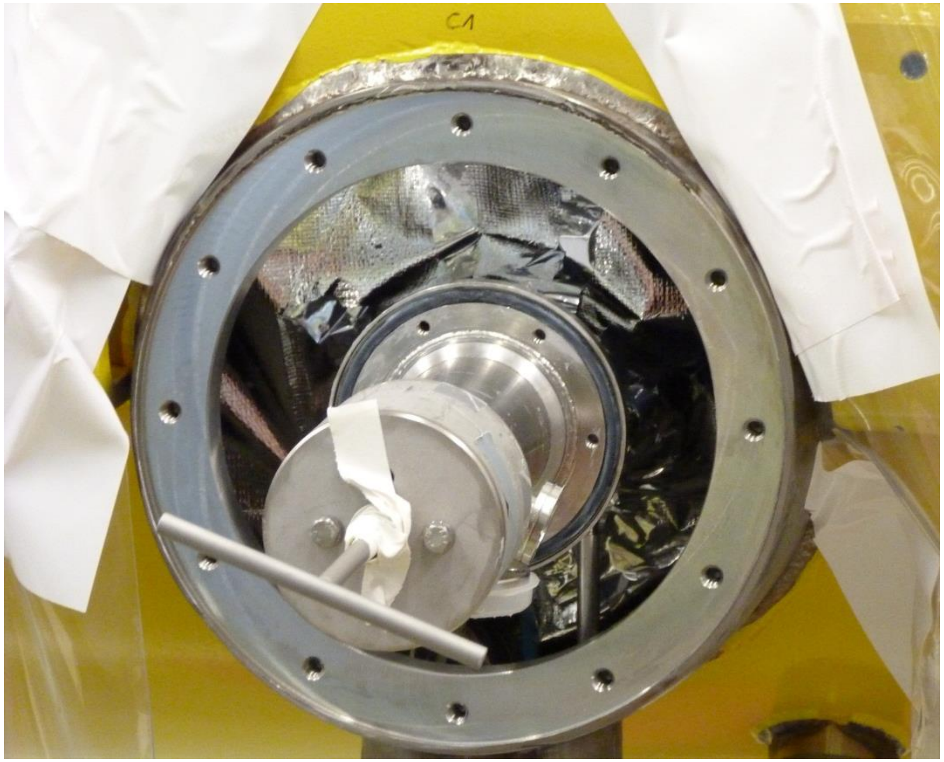
The electrical transfer vehicle is fully operational.
Spares have been ordered for all critical parts (e.g. battery, etc…)

Assembly prototyping at Saclay

5. Cold Mass insertion (CA-WS1)

Assembly prototyping at Saclay

6. Coupler Warm Part assembly (CO-WS1&2)
   - 6.a coupler warm part assembly
   - 6.b coupler pumping line assembly



Assembly prototyping at Saclay

7. Final control and shipment (SH-WS1&2)

Challenge : Tooling vs. Ind^{ial} Contract

Ideally the tooling definition should be included in the industrial contract.

This was impossible with our project timeline and readiness: e.g. the clean room was delivered in Nov. 2009.

The contract specifies that the Industrial Operator is only responsible of the standard tools, while CEA is responsible for the specific tools and their maintenance.

The contract is essentially 'Man and Engineering Power'

As a consequence, the industrial operator will criticize the infrastructure layout and the tooling made available to him:

- e.g. cavity reception area,
- e.g. cavity support and pre-alignment tools in the clean room,
- e.g. layout of shipment vs. VV strorage area

Some of the criticisms come too early, missing the global scheme.

Some of the criticisms will lead to a better optimized production.

Input Data Readiness for the Industry Transfer

30/05/2013

@	CfT	Kick-off	Prod
• Infrastructure and Tooling	80%	90%	100%
(in the broad sense, e.g. cavity supports)			
• Cryomodule Configuration	70%	85%	100%
• Cryomodule Documentation			
– PBS (or MBOM)	30%	70%	100%
– Availability of Drawings	30%	70%	100%
• Assembly Documentation (WBS)			
– Availabitity of Assembly Procedures	50%	75%	100%
– Availabitity of Control Procedures	50%	75%	100%
– Availabitity of Regulation (PED, Safety)	20%	75%	100%

(qualitative %)

Ideally, all ratios should be 100 % (cf. cavity production, or AMTF).

Industry cannot start production w/o 100% of Input Data in their Resource Planning software (ERP)

• Overall Quality of the Process (RF acceptance)	60%	60%	100%

Prototyping by CEA-DESY

Assembly prototyping at Saclay

- Assembly of XFEL prototype cryomodules (PXFEL2 and PXFEL3) at Saclay aims at:
  - Completing the training of the Saclay team;
  - Commissioning the infrastructure (XFEL Village)

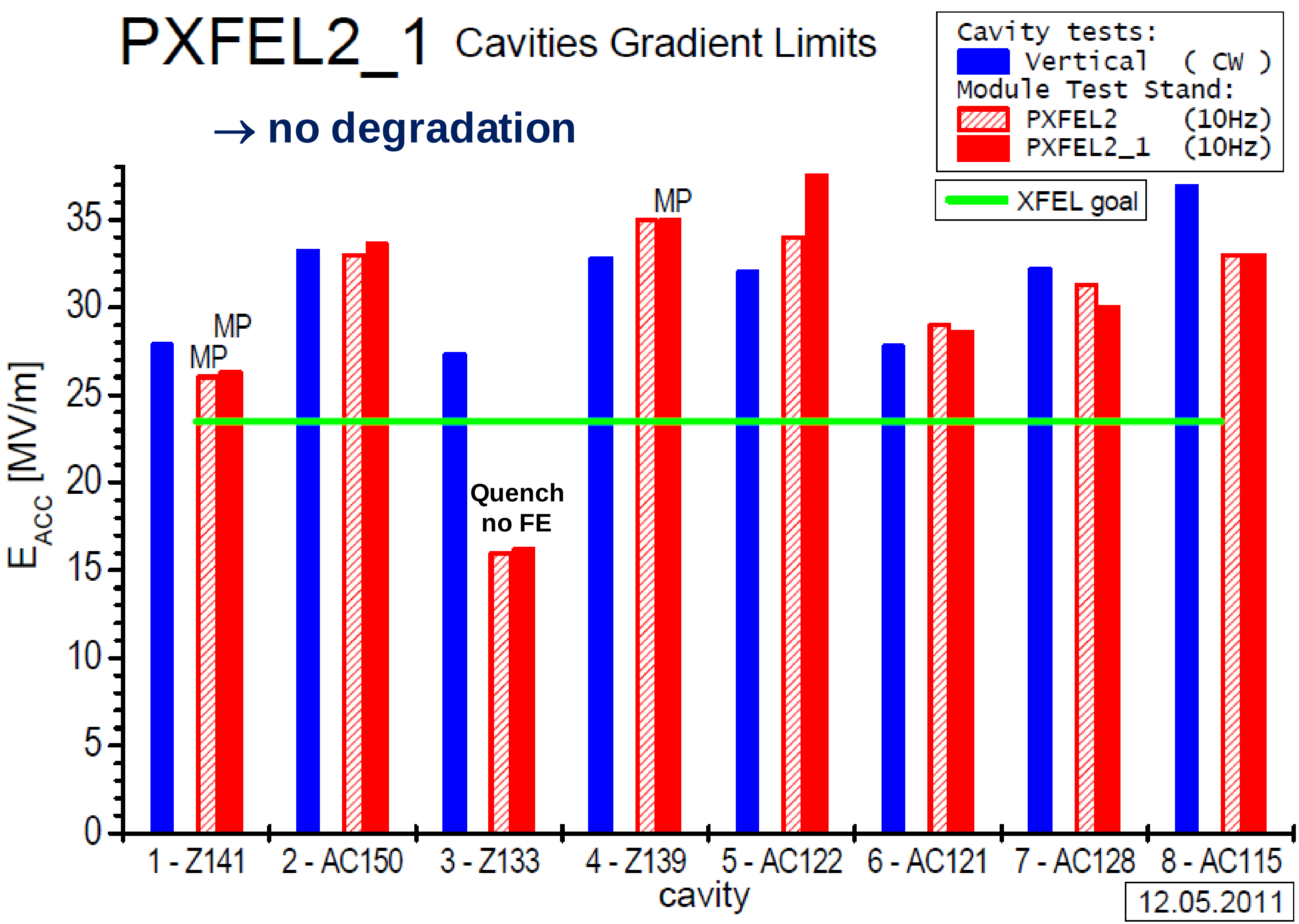
- The team (~10 persons) has operated :
  - the module disassembly of PXFEL2_1 (started 24/08/2010)
  - the module re-assembly of PXFEL2_1
  - the string and module assembly of PXFEL3_1 (02/05/2011 – 26/10/2011)

    using DESY cavity posts and clean room tools
  - the string and module assembly of PXFEL2_2 (30/01/2012 – 04/09/2012)

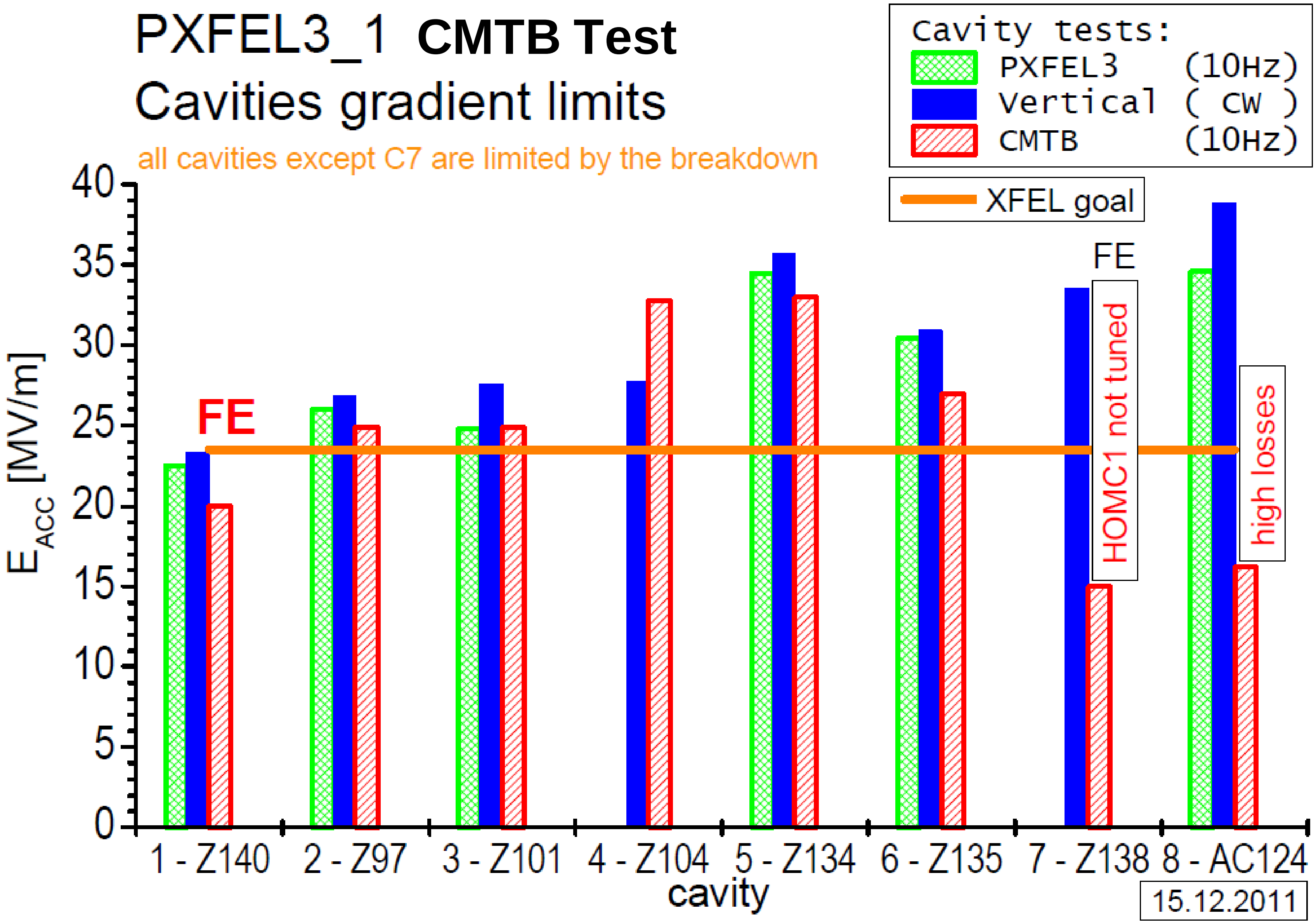
    using CEA cavity posts and clean room tools

- Prototype modules PXFEL2&3 were made from a special production of cryogenic distribution systems ('cold mass') and vacuum vessels, and from 'FLASH' recycled cavities, couplers, tuners, etc…

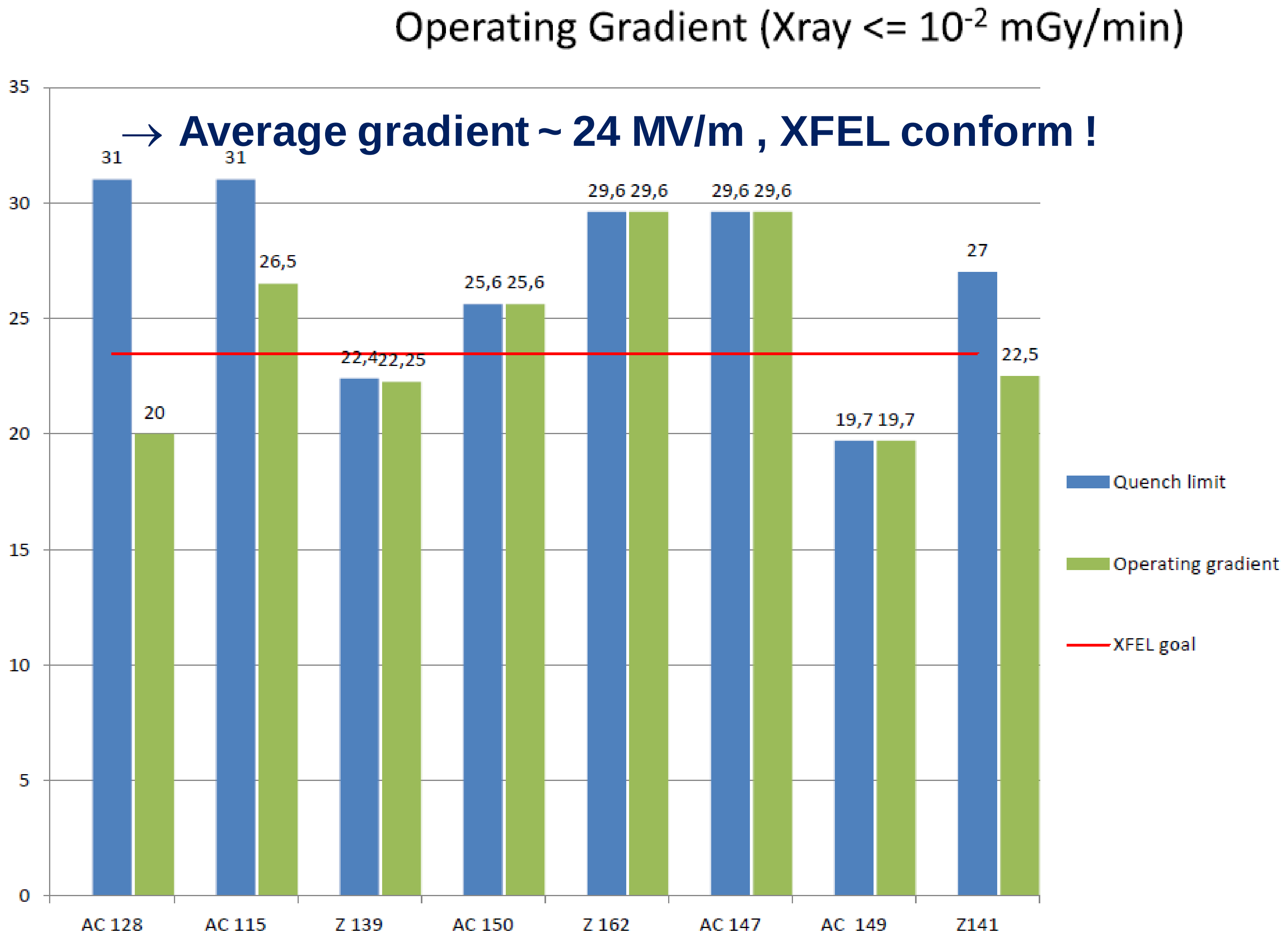
PXFEL2_1 Results



PXFEL3_1 Results



PXFEL2_2 Results



PXFEL2_2 Results

Cavity	Z141	Ac149	AC 147	Z162	AC150	Z139	AC115	Ac128	gate valve
max Gradient	Eacc 25 MV/m fe onset >25 MV/m	Eacc 27 MV/m fe onset 27MV/m	Eacc 37,6 MV/m FE onset > 37 MV/m	Eacc 29 MV/m fe onset 26 MV/m	Eacc 34 MV/m fe onset > 34 MV/m	Eacc 39 MV/m fe onset >39 MV/m	Eacc 33 MV/m fe onset >33 MV/m	Eacc 32 MV/m fe onset > 32 MV/m	
	Cv 8	CV 7	CV 6	CV 5	CV 4	CV 3	CV 2	CV 1	

											average	operation
before assembly	24,5	27	37,6	29	33	39	33	32	VT	Quench limit	31,89	29,63
before assembly	24,5	27	37	26	33	39	33	32	VT	FE limit	31,44	28,88
after assembly	27	19,7	29,6	29,6	26,6	22,4	31	31	CMTB	Quench limit	27,11	25,68
after assembly	22,5	19,7	29,6	29,6	25,6	22,2	26,5	20	CMTB	FE limit	24,46	22,88
	-	--	--	++	-	--	-	--				

cavity n°6 replaced at DESY (leak on He tank at Saclay)

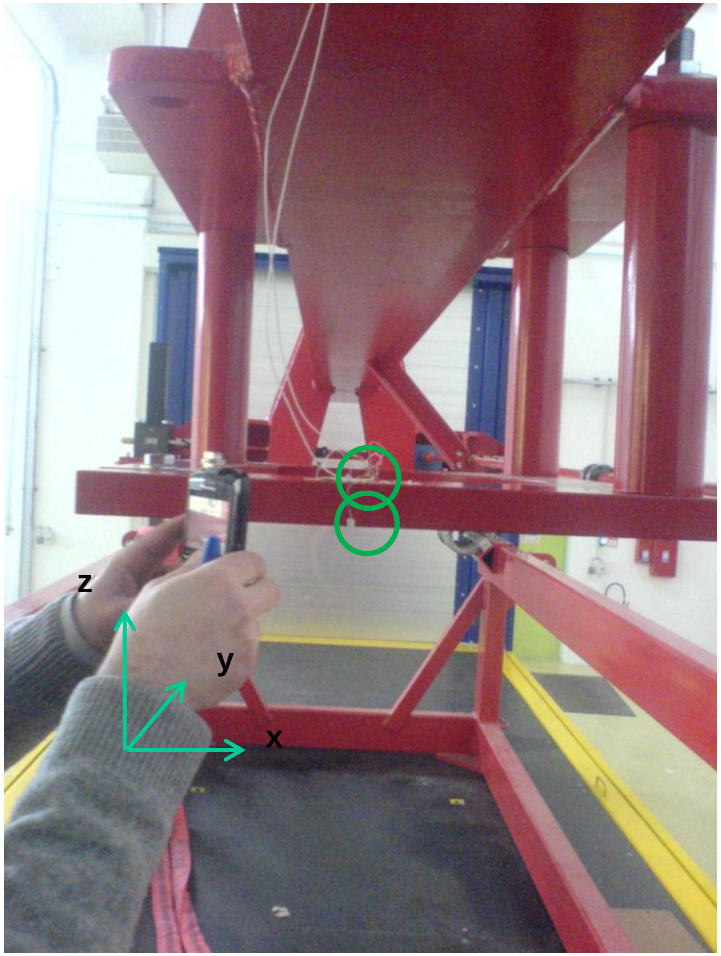
Conclusion

- seven cavities are degraded ☹ with ΔEacc = 7 MV/m lost on average ☹
- very strong field emission on cavity n°1 (AC128), again ! ☹☹ (*string vented and pumped from cavity n°1 end*)
- Z162 has experienced two cold coupler connections, with the same coupler ☺
- all cavities but Z139 (position n°3) have suffered from one (seldom two) non-conformity during the cold coupler or string assembly (*e.g. water in the angle valve body*)
- AC128 (pos. n°1) and AC115 (pos. n°2) share the same non-conformity, namely the accidental fast venting of the common coupler traveling waveguide box.

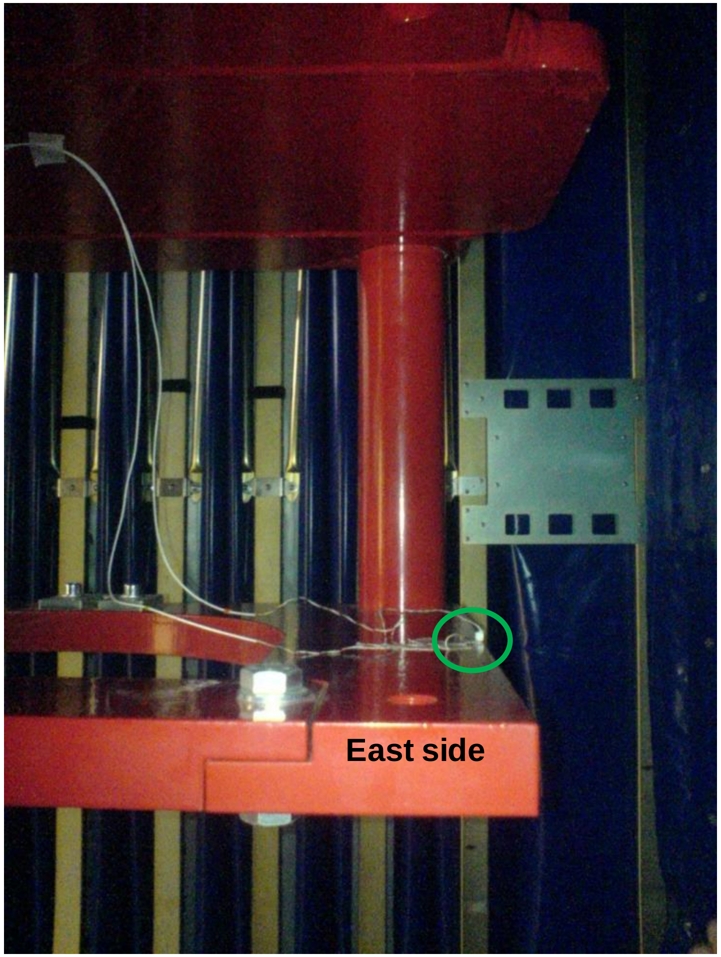
Vibration Measurements

(on an empty girder)

Accelerometers on the Transport Girder

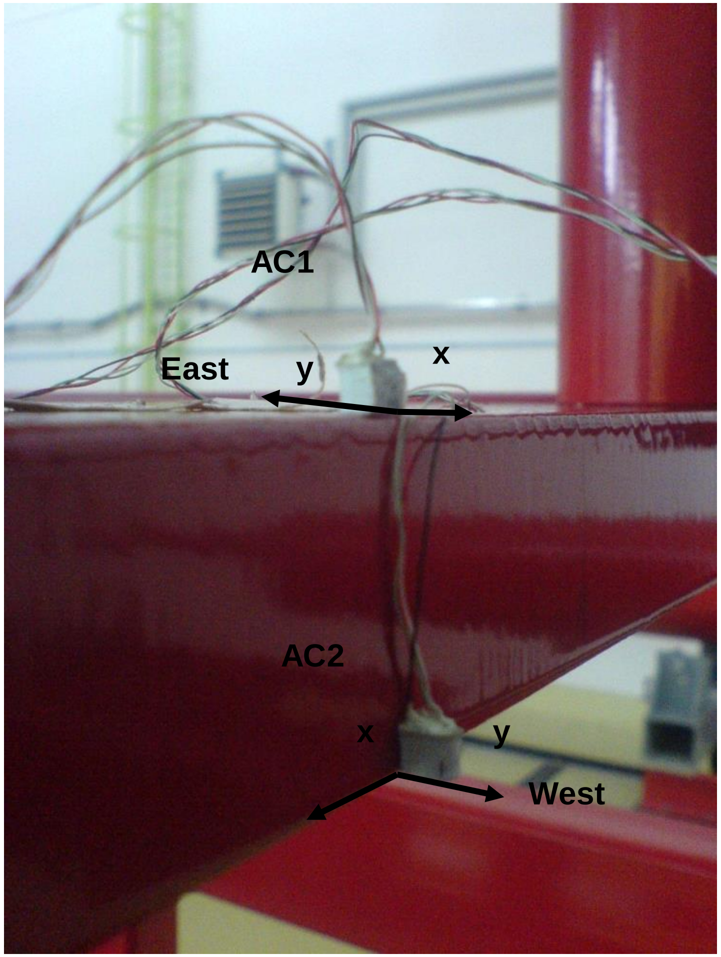


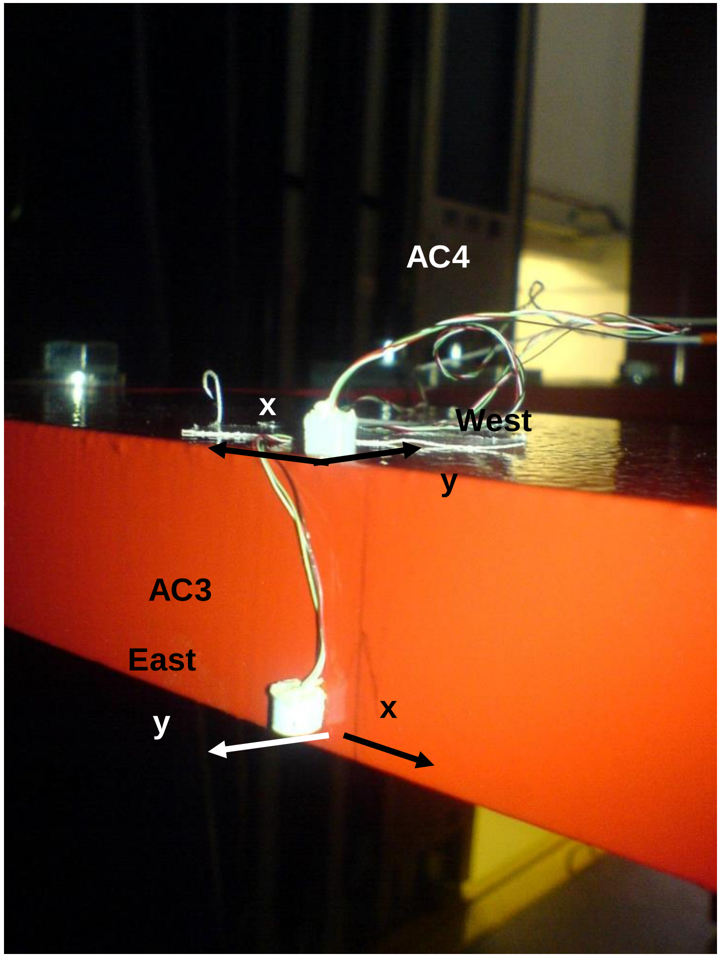
Middle Post : AC1 et AC2



Upstream end : AC3 et AC4

Orientation accéléromètre :



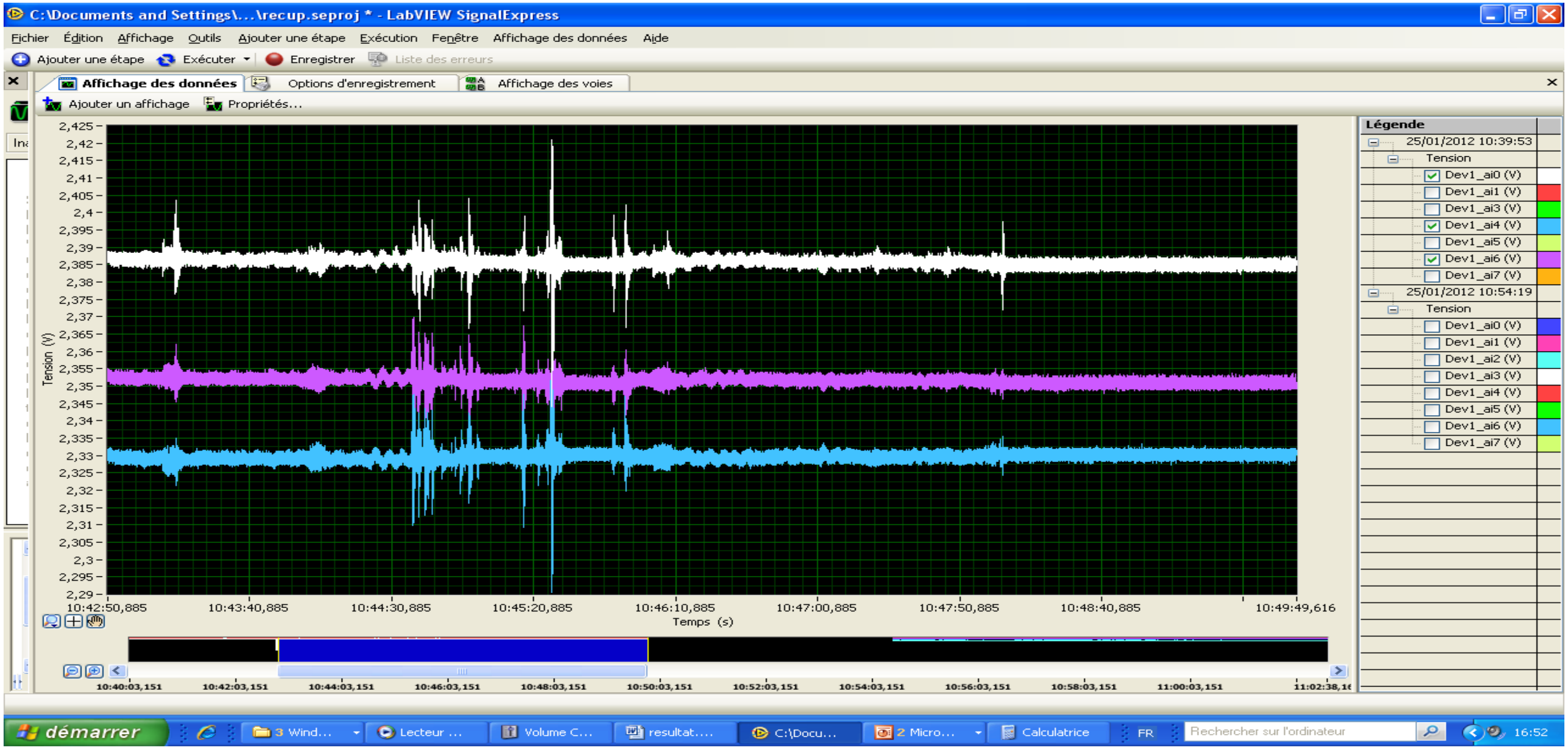


Exiting through the door from B126 to inner Yard

- Signal Amplitude = 10,4 mV. Sensitivity of accelerometers = 87mV/g.
- Acceleration is about 0,12 g along x-axis (transverse horizontal)

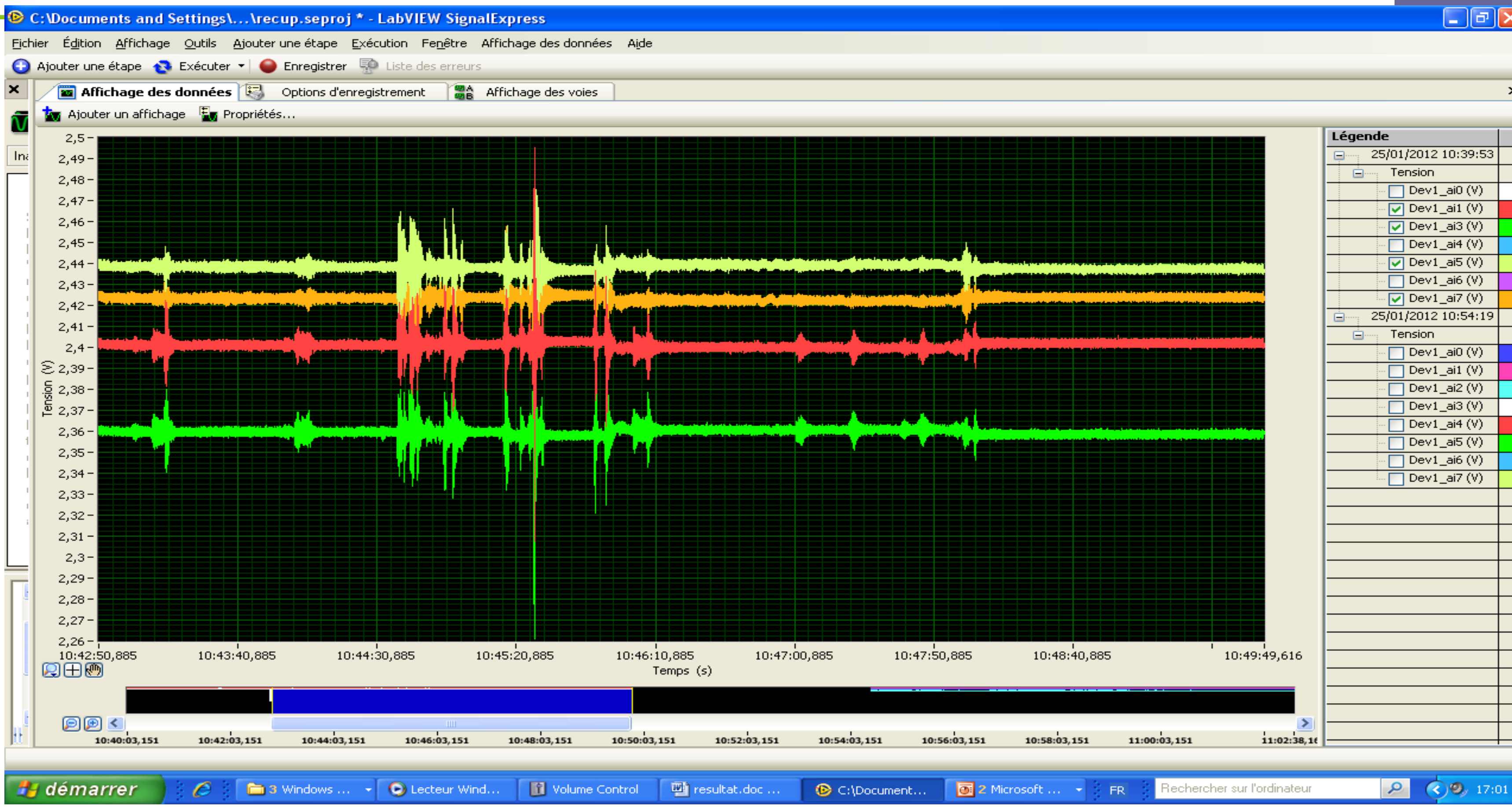
- Acceleration is about 0,17 g along x-axis (longitudinal)

Transfer of the (empty) girder on the alignement pillars (b124)



x-axis (transverse horizontal)

- first (short) signal is girder take-off from the frame: 0,34 g at the center.
- second (long) signal is positioning on the pillars: 0,87g maximum



y-axis (longitudinal)

- first (short) signal is girder take-off from the frame: small
- second (long) signal is positioning on the pillars: 2,3 g (center) et 1,2g (upstream end)

Conclusions

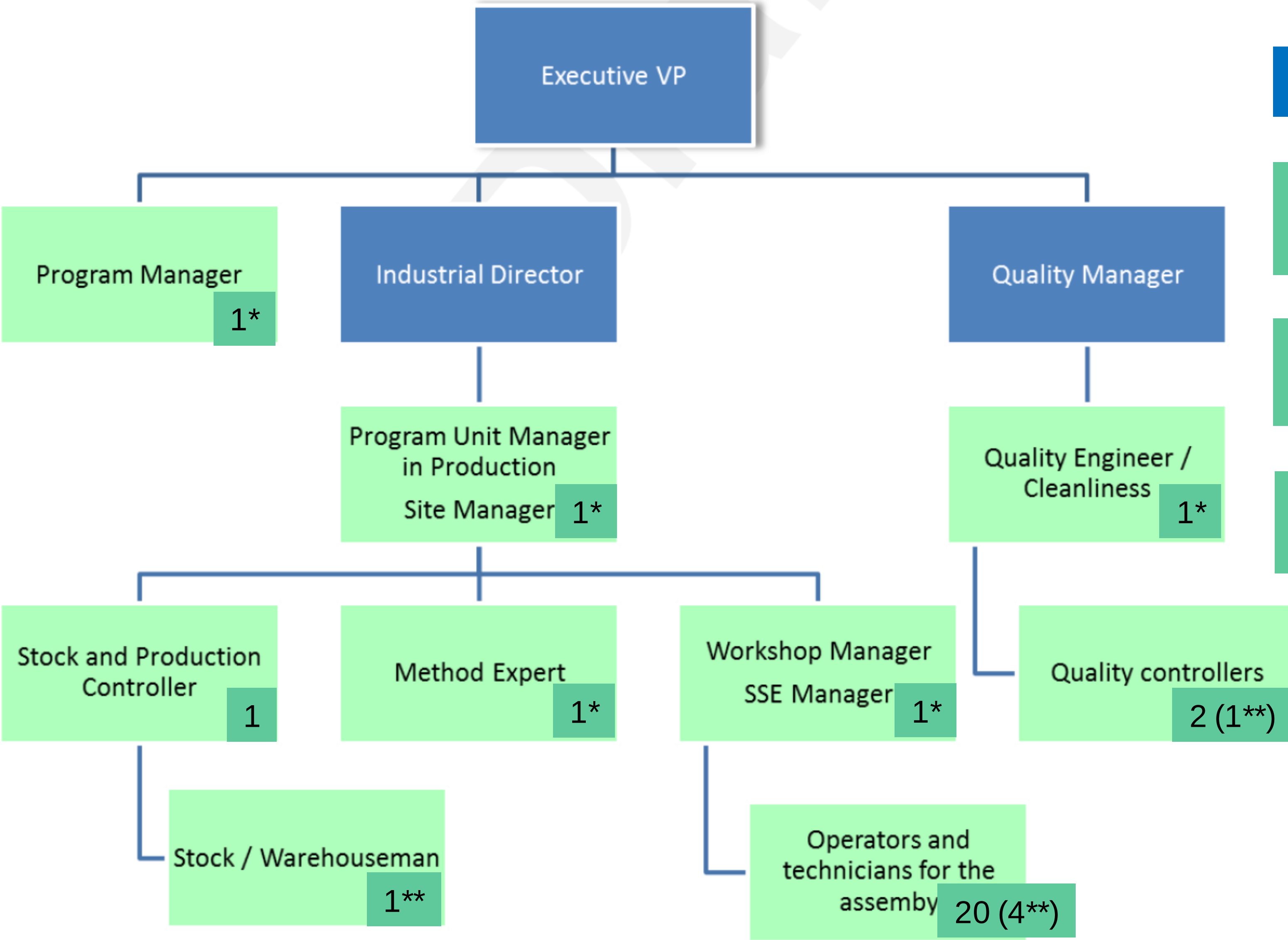
- Vibrations are large, especially for the vented string, however PXFEL2_1 RF was not degraded.
- New measurement campaign with XM-2 transfer rom Roll-out till Warm Coupler workstations

Assembly Industrialization

Selection of Industrial Contractor

- Tender process: ALSYOM, lowest bidder / best technical offer, has been selected by CEA.
- The contract has to be awarded on 27 July 2012 for the integration of 83 cryomodules + 20 in option.
- Up to 29 people will be on Saclay site during ~2 ½ years
- Kick-off meeting : 05/09/2012
- Review of Quality Plan and Management Plan : 27/09/12 with DESY
- After 9 months collaboration, these people are GOOD and the CEA-Alsyom collaboration is EXCELLENT !

Industrial Contract : ALSYOM Management Plan



Off site

29 persons on site

* from mid-sept. 2012

** from beg-febr. 2013

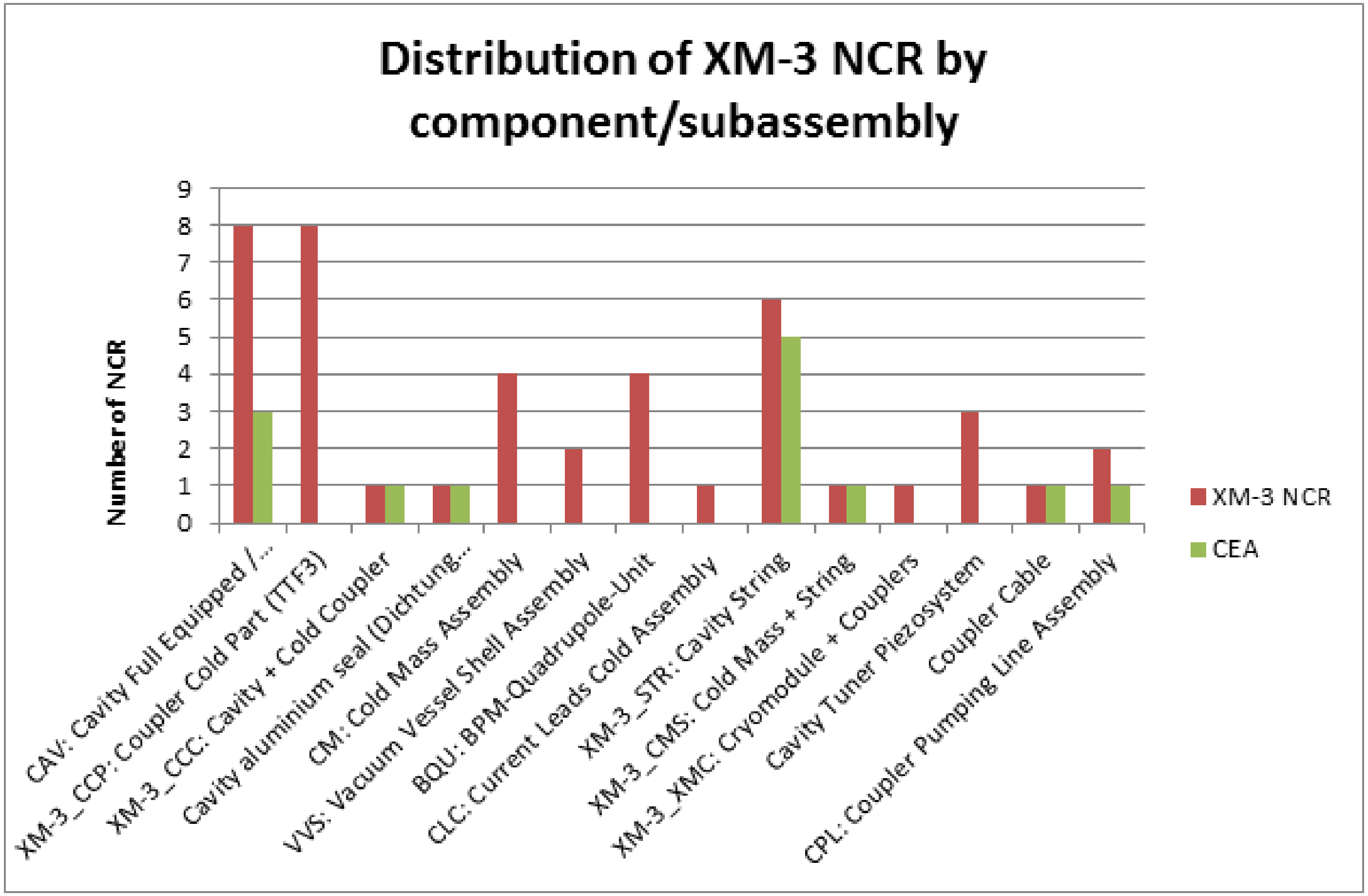
Industrial Contract : Initial Schedule (1/3)

Phase 1: **observation phase** which covers the assembly of XM-3 by CEA with ALSYOM staff as observers.
Initially, this phase starts at T0 (20 August 2012) until T0 + 4 months (20 December 2012).

XM-3 first pre-series module is made with parts from XFEL production lines, except for **cavities** (large-grain RI cavities) and **couplers** (TTF3 RI couplers).

Pre-Series Training Phase: Initial Schedule (1/3 bis)

- **We have observed still many non-conformities**



In total 43 Non-Conformance Reports (NCR) were issued for XM-3, some global, about 13 NCR under the responsibility of CEA: one main reason for 7 month assembly.

Pre-Series Training Phase: Initial Schedule (1/3 bis)

XFEL
X-Ray Free-Electron Laser

- **Cavities Non Conformity**

Irfu / European XFEL	NON CONFORMANCE REPORT		Reference	CEA-XFEL
	~~CHANGE REQUEST~~		Page	1
			Date	23/10/12

EQUIPMENT:	CAVITY	SERIAL NUMBER:	XM-3	FILLED OUT BY:

Occurrence phase :				Integration level :		Workstatio
Control :		Reception :		Part	X	Reception Ha
Manufacturing :		Acceptance :		Subassembly		
Design/validation :		Destockage :		Equipment		
Integration :	x	Others :		Others		

TITLE : Deviation of the Pin in the longitudinal position

DESCRIPTION :

We observed on the cavity AC158 that the assembly of the newly produced magnetic shield was too tight (cf. pictures page 2).
Under the indication from DESY, this led to the systematic measurement of the distance from the middle of the cavity bracket to the
AC158: 103 mm instead of he nominal 93 mm +- 2 mm
This result was reproduced for all eight XM-3 cavities AC114, AC146, AC151, AC152, AC154, AC156, AC157, AC158

Reference documents :

TECHNICAL INVESTIGATIONS :	Responsible (s)

On the cavity was measured a deviation on the PIN (draw. 02L, pos. 4) in the longitudinal position:
The nominal distance from the cavity bracke centert to the PIN center is 93mm – measured ~103mm
The nominal distance from the coupler flange center to the PIN is (100,02mm) – measured ~96mm

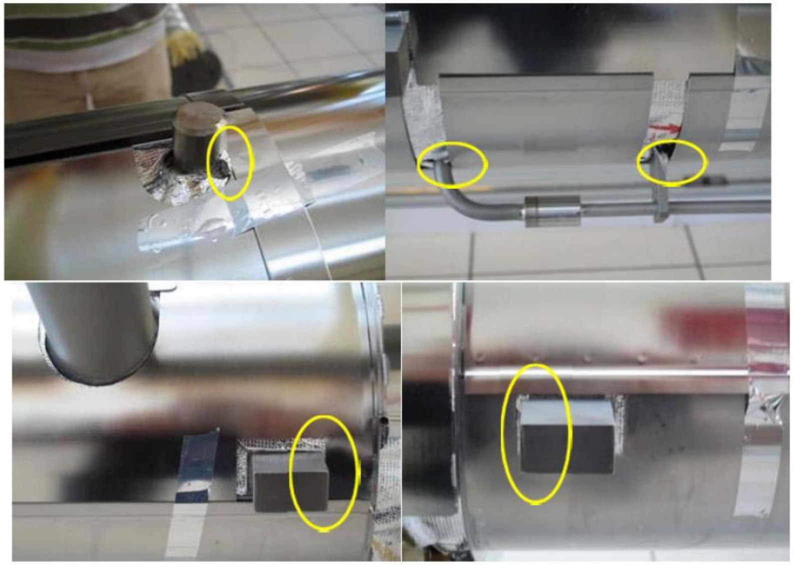
CORRECTIVE ACTIONS (item concerned by NCR/CR)	Responsible (s) :	CLASS :
The connection of the cavity string to the cold mass will have to be given a particular attention in view of the shrinkage of the cold mass during cool-down.		MINOR :
		MAJOR :
		FINAL DECISIONS :
		USE AS IS
		WAIVER
PREVENTIVE ACTIONS (further item) :	**Responsible (s) :**	REPAIR
Check of the helium tank dimensions for the industrially produced cavities.		DOCUMENTATION CHANGE
		SCRAP
		MODIFICATION
		ACTION ON OTHER PRODUCT

Clearance for actions	Technical Manager	Quality Assurance Manager	Project
CEA	J-P. Charrier	C.Cloué	O.N
Accelerator Consortium manager :	D. Reschke (CO)	-	E. Vog

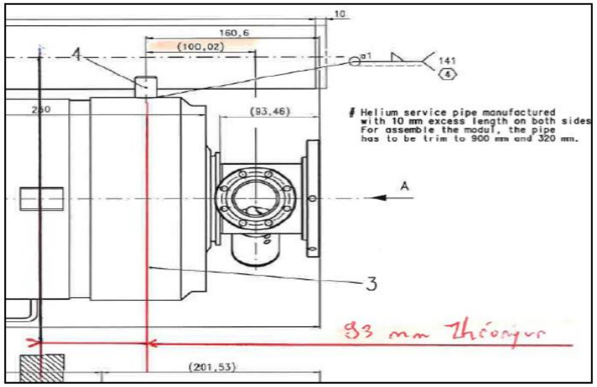
Irfu / European XFEL	NON CONFORMANCE REPORT / CHANGE REQUEST	Reference	CEA-XFEL
		Page	2
		Date	23/10/12

CONTINUATION SHEET

Assembly of the magnetic shield on the cavity AC158 :



Cavity drawing :



Pre-Series Training Phase: Initial Schedule (1/3 bis)

XFEL
X-Ray Free-Electron Laser

- **Couplers Non Conformity**

Irfu European XFEL

NON CONFORMANCE REPORT

Reference :	CEA-XFEL-RNC-13-073		
Page :	1		
Date :	19.03.2013		
Enter either the "Physical Part EDMS-ID", or the "Fab. Part Name" + "Fab. Part EDMS-ID" + "Physical Part Serial Number".		Physical Part EDMS-ID :	??
Fab. Part Name : ??	Fab. Part EDMS-ID : ??	Physical Part Serial No.	??
Recorded by : O. Napoly	Location : CEA XFEL Coupler Area		
TITLE :	Water and broken ceramics in the cold part of the coupler AC3C28		

DESCRIPTION :

When opening the cold ceramics cap of coupler AC3C28 connected to cavity n°4 of XM-3, we observed:
1) water falling out of the cap, and indeed the copper coating is oxidized (cf. pictures n°1 and n°2).
Water may have entered the cap though the valve during the washing of the coupler pair since one can see a trace of oxidation inside the cap in front of the valve hole (cf. picture n°3).
The level of water staying in the cap for about 6 months, is indicated by the darker lower area on the picture.
2) a broken ceramics (cf. pictures n°1 at 4h30 orientation, and n°4).
One can see traces of broken ceramics on the cap (cf. picture n°5) and also on the tool (cf. picture n°6).

Reference documents :

TECHNICAL INVESTIGATIONS :	Responsible (s)
1) The location (flange, valve, feedthrough) of the water leak from the washer-dryer is under investigation. There is no indication that the valve was loose. 2) We are investigating when the breaking of the ceramics happened: due to the presence of water, it could have happened only before the washing of the coupler pair, or when opening the ceramics cap.	S. Berry, F. Hoffmann

CORRECTIVE ACTIONS (on Physical Part, or Equipment) :	Responsible (s)
1) The oxidation of the copper coating was removed by wiping it with sullfamic acid and rinsing with ethanol. Unfortunately, the copper coating has been localy removed completely (cf. picture n°7) 2) The broken ceramics piece was removed and the sharp brazing material layer (cf. picture n°8) was bend and folded as much as possible to prevent sharp edges.	S. Berry, F. Hoffmann

PREVENTIVE ACTIONS (on Fabrication Part, or Equipment) :	Responsible (s)
1) Do not enter the cold coupler pairs in the ISO4 clean room through the washer-dryer until the origin of the water leak is found. 2) Preventive actions will be defined when the origin of the ceramics breaking is found.	S. Berry

CATEGORY :		FINAL DECISIONS :	
Minor :		Action on Part :	Repair
Major :	X	Documentation :	

Clearance for actions	Fabrication Engineer (Technical Manager)	Quality Manager	Project Manager (WPL)
Unit responsible for involved product :	S. Berry, T. Trublet	C. Cloué	O. Napoly
Accelerator Consortium Manager :	E. Vogel	-	W. Kaabi, W-D. Möller

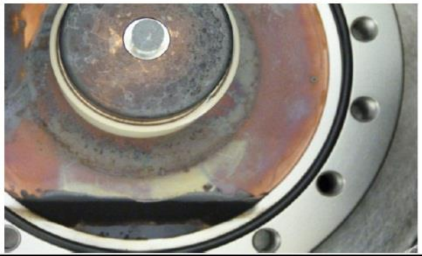
Irfu European XFEL

NON CONFORMANCE REPORT

Reference :	CEA-XFEL-RNC-13-073
Page :	2
Date :	19.03.2013

CONTINUATION SHEET

Picture n°1



Picture n°2

Pre-Series Training Phase: Initial Schedule (1/3 bis)

XFEL
X-Ray Free-Electron Laser

- **Alignment CEA Procedure Non Conformity**

Irfu | European XFEL

NON CONFORMANCE REPORT

Reference :	CEA-XFEL-RNC-12-068
Page :	1
Date :	20.12.2012

Enter either the "Physical Part EDMS-ID", or the "Fab. Part Name" + "Fab. Part EDMS-ID" + "Physical Part Serial Number".

Physical Part EDMS-ID :					
Fab. Part Name :		Fab. Part EDMS-ID :		Physical Part Serial No.	XM-3
Recorded by :	O.Napoly/M.Fontaine	Location :	CEA XFEL Alignment Area		
TITLE :	Cavity Alignement				
DESCRIPTION :	Problems during the cavity and quadrupole alignment				

The alignment of the cavities and quadrupole of XM-3 has been repeated three times until reaching a correct alignment.
1) During the first attempt (23/01/13), cavities n°1 to n°5 were released by mistake from the invar rod, hence shifting significantly from their longitudinal position.
2) Affer the second attempt (30/01/13), alignment was off tolerances mainly due to a wrong definition of the reference frame. The proper defintion was then instructed by DESY.
3) At the third attempt (08/02/13), alignment was on tolerances with good agreement between CEA and DESY data, but two **needle** bearings were found loose (cavity n°3 and n°5, tbc).
4) At the fourth attempt (20/02/13), the allignment was accepted by DESY, with a derogation for longitudinal position of the quadrupole (cf. Picture n°1).
XM-3 assembly was continued.

Reference documents :

TECHNICAL INVESTIGATIONS :	Responsible (s)
1) Prior to transverse alignment, cavities n°1 and n°3 were found 3 mm upstream from their nominal longitudinal position. The middle cavity n°5 was found 1.5 mm away from its nominal position. By mistake, cavities n°1 to 5 were unfastenned from the Invar rod: as a result, the string expanded towards its upstream end and cavity n°1 has been measured 14 mm off longitudinally. 3) the torques of the bush screws was checked systematically on the coupler side of the cavity string (vertical and horizontal bushes). The torque of the bushes pushing the loose needles bearings were not on specifications.	M. Fontaine, J-P. Charrier

CORRECTIVE ACTIONS (on Physical Part, or Equipment) :	Responsible (s)
1) DESY sent us the tools needed to displace the cavities longitudinally and the longitudinal alignment of the string was corrected (25/01/13). 2) CEA implemented the correct reference frame in the post-processing of the raw data. Agreement was then reached with DESY. 3) The torque of the bushes was checked along the string.The two bushes of cavity n°3 and n°5 were found incorreclty fastened. This is attributed to their seizure since the problem was fixed after manipulation of the bush by hand. Some bushes were dismounted and in one case the springs were not correctly piled up.	M. Fontaine, J-P. Charrier

PREVENTIVE ACTIONS (on Fabrication Part, or Equipment) :	Responsible (s)
3) In order to prevent the seizure of the bushes, it is envisaged to use vacuum grease. The depth of the bushes will also be checked In general, CEA will implement the practice where the surveyor is not involved in the cavity-quadripole re-alignment operations.	K. Jensch, J-P. Charrier

CATEGORY :		FINAL DECISIONS :	
Minor :		Action on Part :	
Major :	X	Documentation :	

Clearance for actions	Fabrication Engineer (Technical Manager)	Quality Manager	Project Manager (WPL)
Unit responsible for involved product :	M. Fontaine, J6P. Charrier	C. Cloué	O. Napoly
Accelerator Consortium Manager :	E. Vogel		K. Jensch, M. Schlösser

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NON CONFORMANCE REPORT

Reference :	CEA-XFEL-RNC-12-068
Page :	2
Date :	20.12.2012

CONTINUATION SHEET

Picture 1: Final alignment data

XM-3 after adjustment (20.02.2013) measurement by CEA

DESY - MEA2 (Vermessung)

Entrance (E) and Exit (A) Cavity Offsets
Y = lateral, Z = height
Tolerance = 0.3mm

Group To Group Relationship
Groups: E_A to E_A (Reported in Nominalwerte::Modul)

Name	E_A-Nominal Y1	Z1	E_A Y2	Z2	Delta dY	dZ
C1-E	0.24	0.00	0.16	-0.12	-0.08	-0.12
C1-A	0.24	0.00	0.27	0.07	0.03	0.07
C2-E	0.24	0.00	0.27	-0.17	0.03	-0.17
C2-A	0.24	0.00	0.04	-0.05	-0.20	-0.05
C3-E	0.24	0.00	0.03	-0.12	-0.21	-0.12
C3-A	0.24	0.00	0.08	-0.16	-0.16	-0.16
C4-E	0.24	0.00	0.23	-0.15	-0.01	-0.15
C4-A	0.24	0.00	0.01	-0.06	-0.23	-0.06
C5-E	0.24	0.00	0.31	0.07	0.07	0.07
C5-A	0.24	0.00	0.21	0.24	-0.03	0.24
C6-E	0.24	0.00	0.12	-0.11	-0.12	-0.11
C6-A	0.24	0.00	0.03	0.04	-0.21	0.04
C7-E	0.24	0.00	0.52	0.13	0.28	0.13
C7-A	0.24	0.00	0.16	0.15	-0.08	0.15
C8-E	0.24	0.00	0.25	-0.00	0.01	-0.00
C8-A	0.24	0.00	0.34	0.28	0.10	0.28
Q-E	0.00	0.00	-0.01	0.04	-0.01	0.04
Q-A	0.00	0.00	0.01	-0.11	0.01	-0.11

Coupler (Koppler) Cavity Offsets
X = longitudinal
Tolerance = 1.0mm

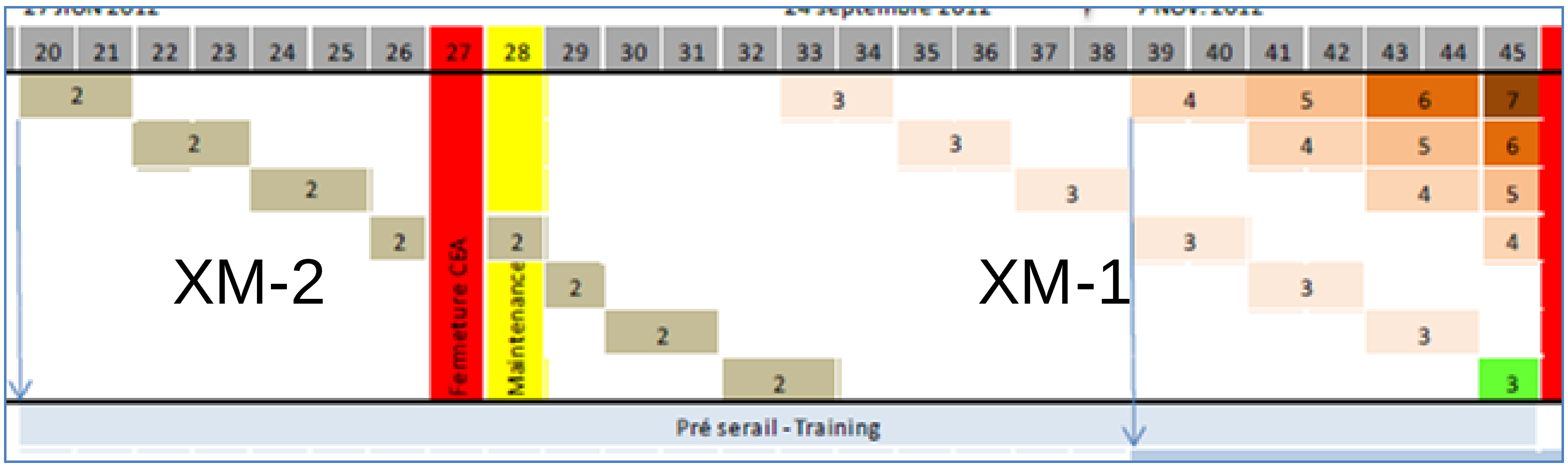
Group To Group Relationship
Groups: Koppler to Koppler (Reported in Nominalwerte::Modul)

Name	Koppler-Nominal X1	Koppler X2	Delta dX
C1-Koppler	-4907.05	-4907.97	-0.92
C2-Koppler	-3522.90	-3523.13	-0.23
C3-Koppler	-2138.75	-2139.24	-0.49
C4-Koppler	-754.60	-755.09	-0.49
C5-Koppler	629.55	629.27	-0.28
C6-Koppler	2013.70	2013.85	0.15
C7-Koppler	3397.85	3397.74	-0.11
C8-Koppler	4782.00	4781.56	-0.44
Q-Center	5096.50	5097.62	1.12

The Cavity Alignment Procedure had to be repeated 4 times, essentially due to mishandling by CEA and a technical problem on the needle bearings fixtures:
→ 1 calendar month, instead of 3 days.

Industrial Contract : Initial Schedule (2/3)

Phase 2 : **training phase** which covers the assembly of XM-2 and XM-1 by mixed CEA-Alsyom teams (co-activity or transfer of knowledge) from **T1 = T0 + 4 months** till **T1 + 6 months**.

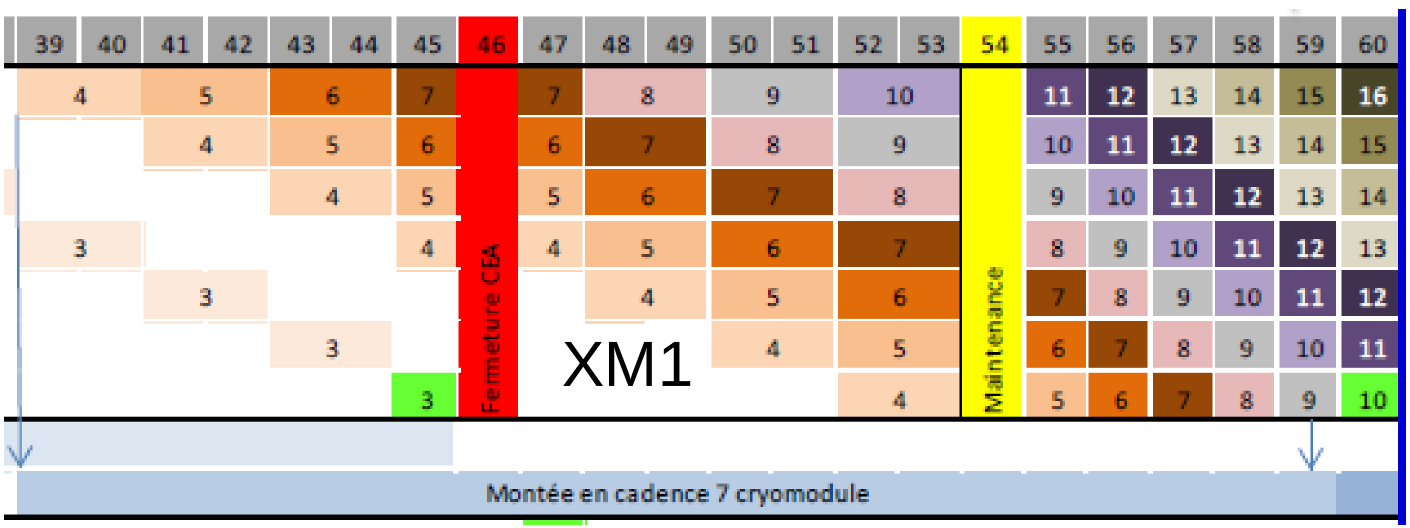


XM-2 first pre-series module is being made with parts from XFEL production lines, e.g first eight EZ **cavities**, except for **couplers** (TTF3 RI couplers).

Industrial Contract : Initial Schedule (3/3)

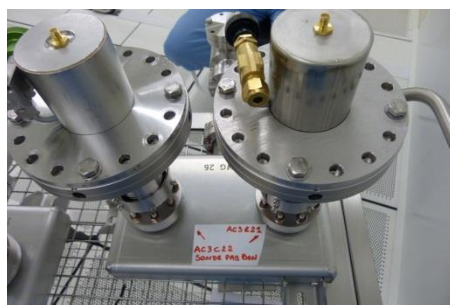
Phase 3: **production phase** which covers the assembly of XM1 to XM80 by Alsyom from **T2 = T0 + 9 months** (20 May 2013) till **T2 + 24 months** (20 May 2015).

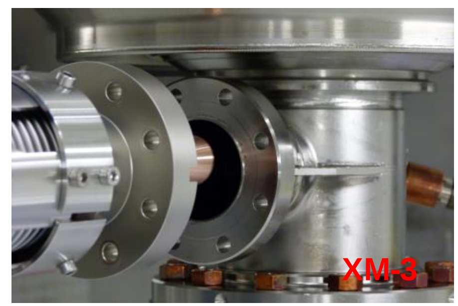
Phase 4 : **production phase (option)** which covers the assembly of XM81 and XM100 by Alsyom from **T3** (5 April 2015) till **T3 + 6 months** (5 October 2015).

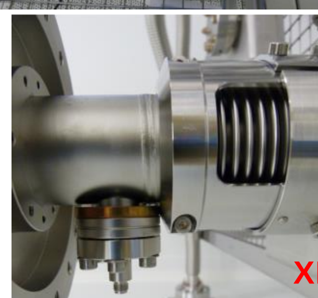


Pre-Series Training Phase: Rationale for Schedule

- **CEA and Alsyom want to assemble XM-1 with XFEL couplers from the Thales-RI production:**
  - No co-activity for the series (XM1-XM100): Alsyom staff do not have the competence to treat properly the non-conformities arising from the new coupler production and new configuration
  - First batch of XFEL couplers expected on 3 June 2013 (HW comm.) which is consistent with the start of XM-1 string assembly mid-June.
  - TTF3 couplers are generating too many assembly problems: ceramics caps, bellow clamps, e-pick-ups, RF antenna.







Pre-Series Training Phase: Rationale for Schedule

- **High financial risk for CEA:**

In case of supply chain interruption (component shortage), CEA will compensate Alsyom with *xx* k€/day for maintaining 29 staff on the Saclay site, *yyy* k€ for dismissing and recruiting after 3 months interruption.

Manufacturing Bill of Material (MBOM) and EDMS

Why a Cryomodule MBOM

In the process of assembling cryomodule, it is mandatory for traceability to **gather, record, process and archive** the complete configuration and fabrication information for each cryomodule

→ MBOM

It uses DESY's Engineering Data Management System (EDMS).

How is it built

EBOM

- In design phase, for a cryomodule which is an assembly of 500 components, one builds a Product Breakdown Structure also called Engineering Bill of Material (EBOM)

MBOM

- For fabrication purposes, one refers to Manufacturing Bill of Material (MBOM)

Cryomodule XMn

- product

Component assembly				Component Reference							
ISO4 SA WS	ISO4 CC WS	ISO4 CC Workstation (Cavity+ColdCoupler)		EDMS-ID	Rev.	Reference dwg	Position	Quantity	q0SubType	F/N	temporary, modifiable, alternate
Cavity String								1	assembly	1	
	Cavity with Cold Coupler							8	assembly	1	
		Cavity Full Equipped / Measured		D*905747, F	F	03L		1	assembly	1	
			Cavity Beamtube Blank Flange - Long Side	D*905747, F	F	03L	2	1	component	1	temporary
			Cavity Beamtube Adapter Flange - Short Side	D*905747, F	F	03L	3	1	assembly	2	temporary
			HOM Antenna	D*905747, F	F	03L	10	2	assembly	3	
			Pick-Up Antenna	D*905747, F	F	03L	12	1	assembly	4	
			High Q Fixed Antenna	D*905747, F	F	03L	15	1	assembly	5	temporary
			Bellow Clamp								
		Coupler Cold Part Assembly									
		Test Wave Guide									
		Blind Flange for TWG									
		Aluminium Seal NW40									
		Coupler Cold Part Assembly Set									
			Threaded Rods M6x40								
			Washer d=6.4								
			CuNiSi Nut M6								
	Q-pole unit assembly after transport										
		Quad-BPM-Vat main body									
		2Ph Pipe Flange Assembly (C)									
		Dichtdeckel Verschaltungsbox (E)									
		Beam Pipe Flange Assembly (A)									
		Flange Assembly (B)									
		Flange Assembly (D)									
	Cavity Bellows			[illegible]	[illegible]			[illegible]	component	[illegible]	

It is collecting, recording, and archiving the complete mandatory fabrication information.

It is focused on the parts that are needed to assemble a CM at CEA. The MBOM also includes information about how the parts relate to each other, the inspection to be performed, the tests to be recorded, the assembly procedures, the documentation etc

Example of information : reference of the drawing, WP leader in charge of the supply serial number … (54 columns, 500 lines)

→ configuration recording of each cryomodule

→ Arborescence documentaire de l'ADP sous EDMS (base documentaire géré par DESY)

MBOM of XM-2 in EDMS

EDMS-ID	Name	Description	Quantity	Work Status
D00000000582927,A,1,1	XM-2_STR: Cavity String	Cavity string assembly for XM-2		Working (in Vault)
D00000000582827,A,1,1	XM-2_CCC: Cavity + Cold Coupler	Cavity with cold coupler assembly for XM-2	8	Working (in Vault)
D00000000572497,A,1,1	BQU: BPM-Quadrupole-Unit	BPM-Quadrupole-Unit, VAT main body and BPM	1	Released
D00000000572557,A,1,1	CBL: Cavity Bellows	Cavity bellows	8	Released
D00000000572567,A,1,1	Cavity Dichtung NW78 (Al seal)	Cavity aluminium seal (Dichtung NW78)	17	Released
D00000000572587,A,1,1	Bellow Cavity Assembly Set	Bellow cavity assembly set	7	Released
D00000000572627,A,1,1	Bellow Qpole Assembly Set	Bellow Qpole assembly set	1	Released
D00000000572637,A,1,1	VGV: Gate Valve Assembly	Gate valve assembly	1	Released

The MBOM defines how a specific part type (fabrication part) is produced and from which components. The part gets fabricated in a physical part and assembled to other physical parts to form one cryomodule.

Control of Physical parts

Physical Part , D00000010472569,A,1,1 , Item Info : Summary

Summary | BOM | Properties | Related Items | Next

Related Items

Has Fabrication Documentation : 5 objects

	Name
	ASS_CR_26,A,1,1
	CTR_CR_16,A,1,1
	REC_CR_3,A,1,1
	SUP_CR_9,A,1,1
	TST_CR_39,A,1,1

Has Description : 1 object

	Name
	IIR_XM-3_CCP TWG36 - AC3C32,A,1,1

Is Instance of : 1 object

	Name
	XM-3_CCP: Coupler Cold Part (TTF3),A,1,1

Is Affected by : 2 objects

	Name
	CEA-XFEL-RNC-12-036,A,1,1
	CEA-XFEL-RNC-12-038,A,1,1

Is Used By Physical Part : 1 object

	Name
	CCC156,A,1,1

Properties

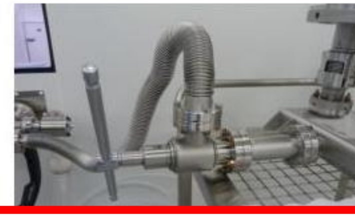
Description:

Preview Image(s)

Type (Instance of)
XM-3_CCP: Coupler Cold Part (TTF3)
…ial Number
…C3C32
…MS ID
…0000010472569

Irfu / European XFEL	G0M n° ASS_CR_26	V5.1
	Coupler venting for coupler cold part assembly	Page 1/6
		Date :22/03/2012

Coupler venting for coupler cold part assembly



1/5

Incoming Inspection Report: Coupler Cold Part

1	General Information (for protocol upload)	
	Project	XFEL_WP00_Alsyom
	Team	XFEL_WP00_Alsyom_Team
	Team Folder	CEA_Templates
	Location	CEA XFEL Reception Area in IS05 Cleanroom

2	Fabriction Part (FP) Information			
	Part	Fabr. Part Name	Fabr. Part EDMS ID	FP Acronym
	TWG	TTF3_TWG: Test Wave Guide	D00000000059257 7	TTF3_TWG
	CCP Position 1	XM-3_CCP: Coupler Cold Part (TTF3)	D00000000057767 7	XM-3_CCP
	CCP Position 2	XM-3_CCP: Coupler Cold Part (TTF3)	D00000000057767 7	XM-3_CCP

3	Physical Part (PP) Information (for relation to Physical Part)				
	Part	PP Serial No.	Manuf. Name	Manuf. ID	Phys. Part EDMS ID
	TWG	TWG36	Laboratoire de l'Accélérateur Linéaire	FRA-LAL-ORS	
	CCP Position 1	AC3C32	Research Instruments GmbH	DEU-RI-0008	
	CCP Position 2	AC3C33	Research Instruments GmbH	DEU-RI-0008	

4	Contact Information		
	Name_Firstname	Kaabi_Walid	Work Package
	Phone number		XFEL-WP05
	Email	[illegible]	

5	Incoming Inspection Result	
	Accepted with reservations (Acceptée avec réservations)	Reservations (Réservations)

6	Received by Operator & Technical Manager		
		Operator	Technical Manager
	Name	G. MONNEREAU	S. BERRY
	Date	15.06.2012	15.06.2012
	Signature		

7	Additional Remarks and Observations

Non-Conformance Reports

Physical Part , D00000010472569,A,1,1 , Item Info : Summary

Summary | BOM | Properties | Related Items | Next Steps | All Versions | Access

Related Items

Has Fabrication Documentation : 5 objec

	Name
	ASS_CR_26,A,1,1
	CTR_CR_16,A,1,1
	REC_CR_3,A,1,1
	SUP_CR_9,A,1,1
	TST_CR_39,A,1,1

Has Description : 1 object

	Name
	IIR_XM-3_CCP TWG36 - AC3C32,A,1,1

Is Instance of : 1 object

	Name
	XM-3_CCP: Coupler Cold Part (TTF3),A,1

Is Affected by : 2 objects

	Name
	CEA-XFEL-RNC-12-036,A,1,1
	CEA-XFEL-RNC-12-038,A,1,1

Is Used By Physical Part : 1 object

	Name
	CCC156,A,1,1

NON CONFORMANCE REPORT	Reference	CEA-XFEL-RNC-12-036
~~**CHANGE REQUEST**~~	Page	1
	Date	25/09/12

EQUIPMENT:	**CCP**	**SERIAL NUMBER:**	**AC3C32 & AC3C33 (TWG 36)** **AC3C27 & AC3C28 (TWG 33)** **AC3C37 & AC3C38 (TWG 23)**	**FILLED OUT BY:**	C.Cloué

Occurrence phase :				**Integration level :**		**Workstation :**
Control :	x	Reception :	X	Part	X	ISO4-CC
Manufacturing :		Acceptance :		Subassembly		
Design/validation :		Destockage :		Equipment		
Integration :		Others :		Others		

TITLE : Cold ceramics caps: missing holes, mis-oriented valves, protruding screws

DESCRIPTION :

Vis du capot de protection de la céramique non-percés + trous de fixation manquants + vannes à positionner

Cold ceramics caps from XFEL-Thales production: missing holes, mis-oriented valves, protruding screws

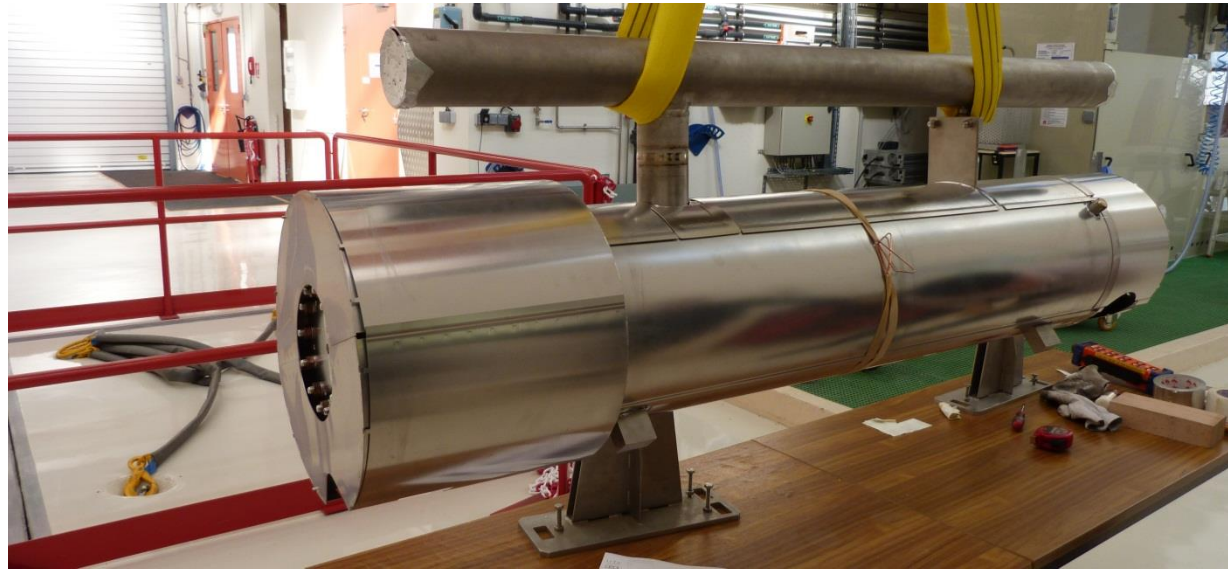
Reference documents :

TECHNICAL INVESTIGATIONS : **Responsible (s)**

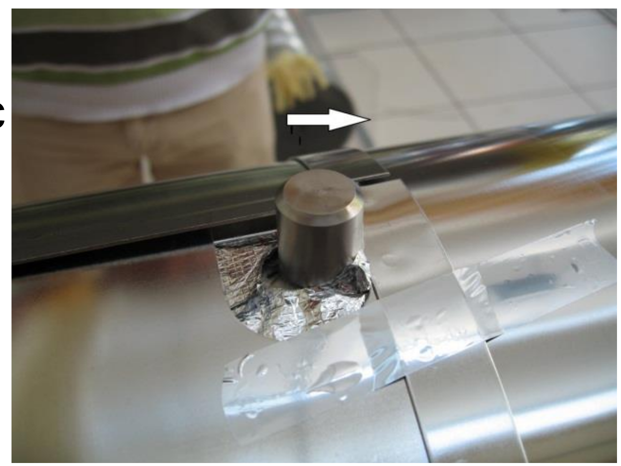
The six cold ceramics caps from the XFEL-Thales production have only 12 holes, instead of 16 like in the corresponding flange of the cold coupler (see picture 1 below). Moreover, the addition of one nut between each screw and the cap and, the mis-orientation of the valve around its fixation point creates a conflict with the cold coupler assembly tool, rendering this assembly impossible as is.
The missing holes will allow the insertion of the only 3 instead of 4 rods necessary to assemble the shells for 70 K interface shells at a later stage.
The functionality of the cap holes is explained in the table below (see picture 2 below)

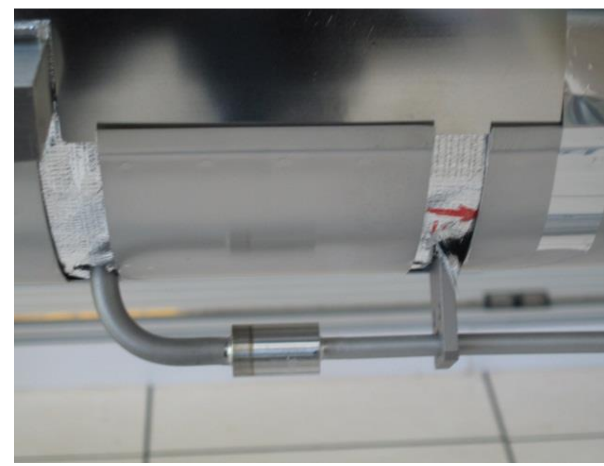
Magnetic Shieldings: PXFELs & XM-3

Prototype by MecaMagnetic for PXFEL configuration (warm-up tube with flange)



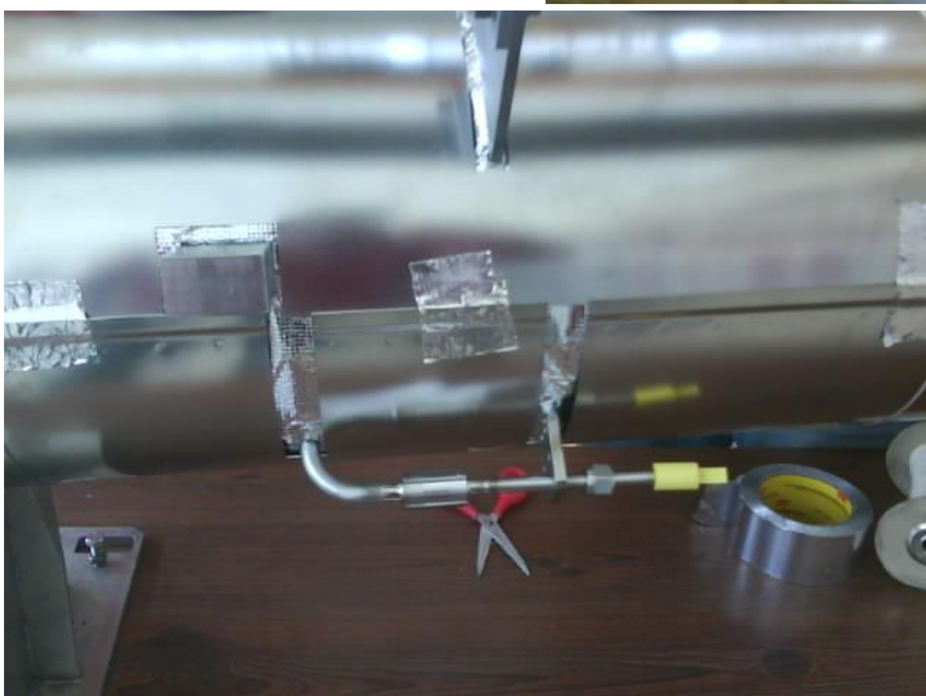
Pre-series by MecaMagnetic for XFEL configuration (warm-up tube with Ti/SS transition): benchmarking XM-3 cavities !





Magnetic Shieldings: XM-2

Pre-series by MecaMagnetic for XM-2 cryomodule

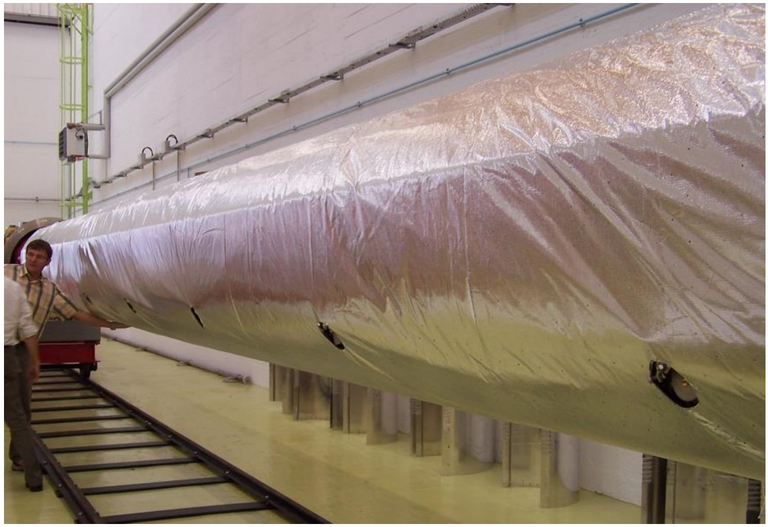


Super-insulation Blankets

Super-insulation blankets have been qualified (PXFEL2_1 and PXFEL3_1).

The 40/80 K super-insulation blanket (2x15 layers):

- costs about 4 k€
- saves 1 day on cantilever and about 7 p.day (balance at ~600 € / day)
- saves about 30 W @ 40 K with respect to multilayers (30 + 29 separators).



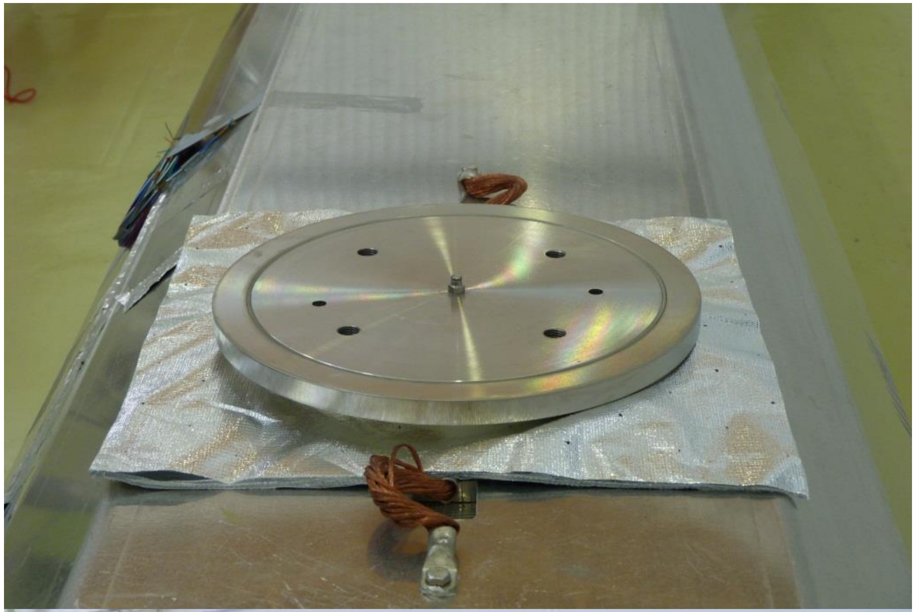
Cryo loss at	PXFEL 3	PXFEL 3_1 cooldown Dec 2011	PXFEL 3_1 cooldown Feb 2012	PXFEL 2_3 cooldown March 2013
40 / 80 K	134 W	96 W	97-102 W	95 W

Negotiations with Jehier allowed about 10% reduction / CfT offer, through:

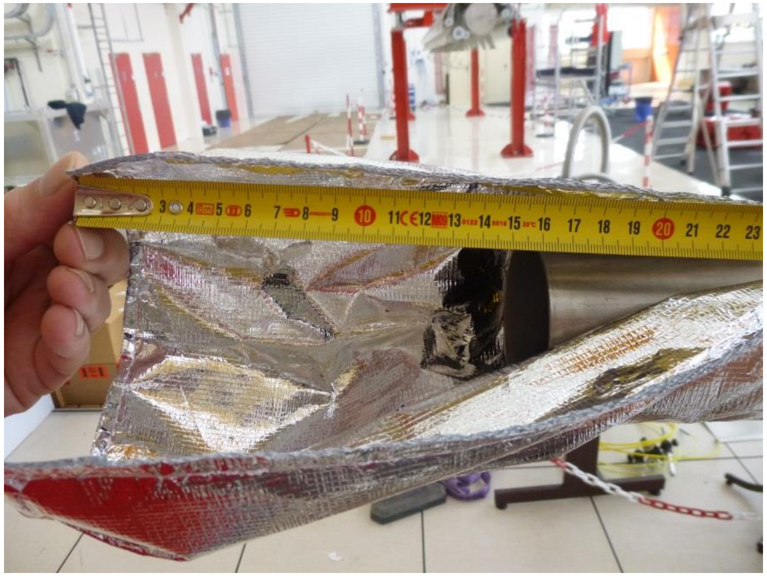
- more flexible (rapid) delivery rate
- simplification of 2K blankets fabrication

70 K blankets ordered in advance for XM-3, XM-2, XM-1 (delivered in June 2012)

70 K Blankets: Prototype by Jehier for PXFEL2_2



2 K Blankets:
Prototype by Jehier for XM-2



ISO4 Procedures

- Alsyom, like many industrial companies, has a long and complete experience of working in clean rooms (ISO5, 400 m^2) and to use equipments in clean environment: e.g. crane, washer-dryer, vacuum and leak detection group, computers, mechanical and survey hardware…

- They have investigation methods and quality insurance methods which were not known to (all of) us: e.g. UV light counting, ISO5 washer, etc…

- Some, including Alsyom, have to learn the specificities of SC RF surface cleanliness and procedures.

Plug Compatibility

Plug Compatibility is not effective in the production, for three main reasons:

1) Management of the configuration and storage
   e.g. DESY BPM vs. Saclay BPM

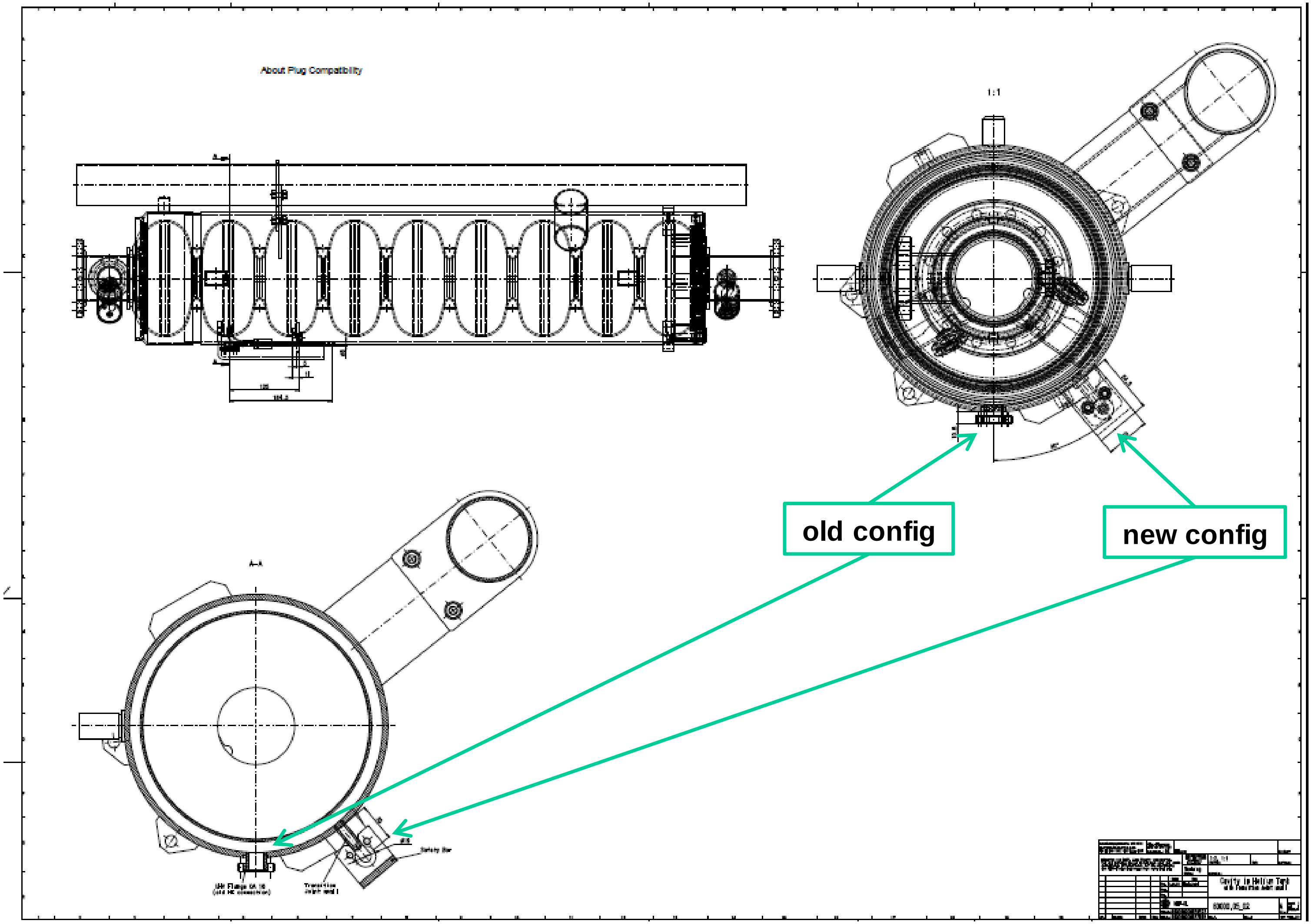
2) Equipment and toolings:
   ~25 % of the assembly time is hands-on cryomodule
   ~75% of the assemly time is tools and equipment

As a consequence, Plug-Compatibility has to envision tooling and equipment.

3) Assembly and control procedures
   Plug-Compatibility leads to multiple assembly and control procedures, by the same staff → high risk of errors.

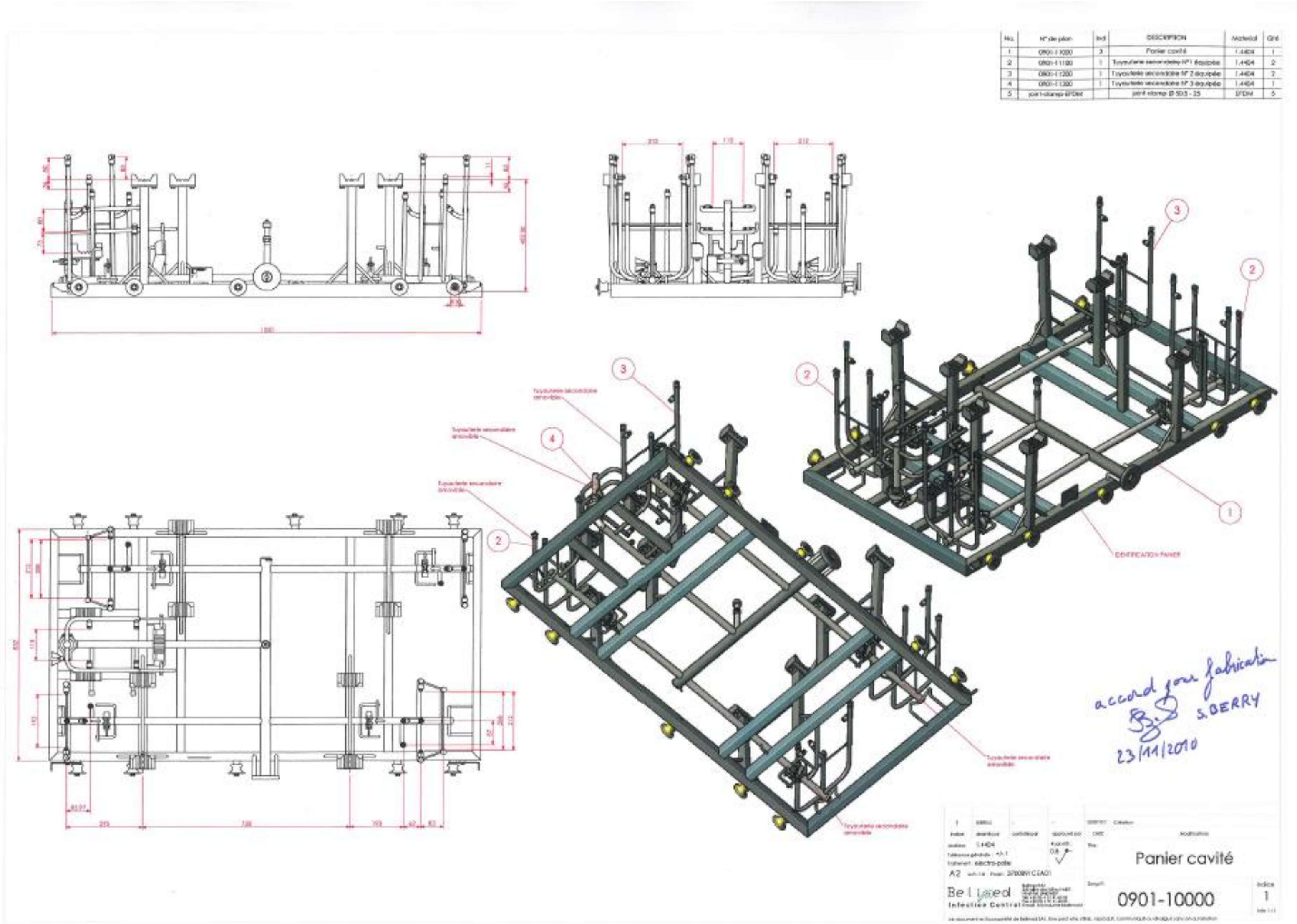
Plug Compatibility

Example of the change of He tank configuration…



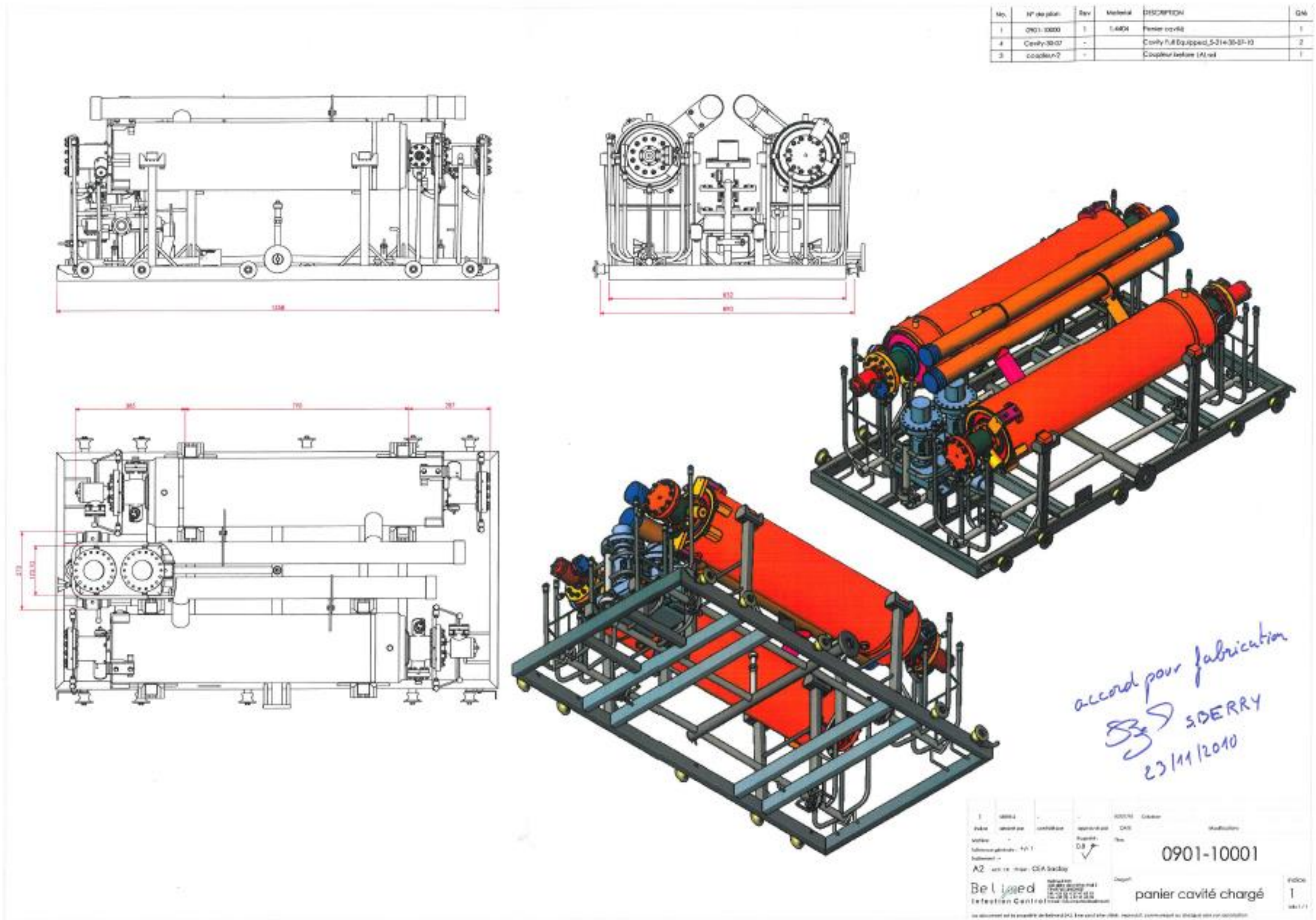
Plug Compatibility

… and its impact on the washer tray



Plug Compatibility

… and its impact on the washer tray



Plug Compatibility

… and ISO4 lifting tools, and later storage equipment, etc…