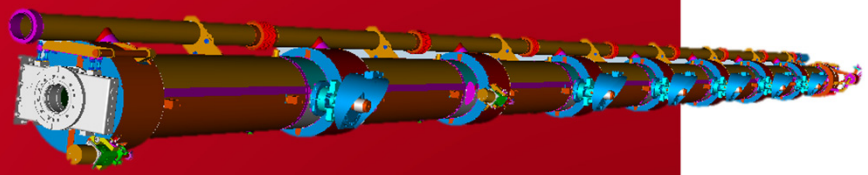
DE LA RECHERCHE À L'INDUSTRIE

CHALLENGES TO ASSEMBLE 100 CRYOMODULES FOR E-XFEL

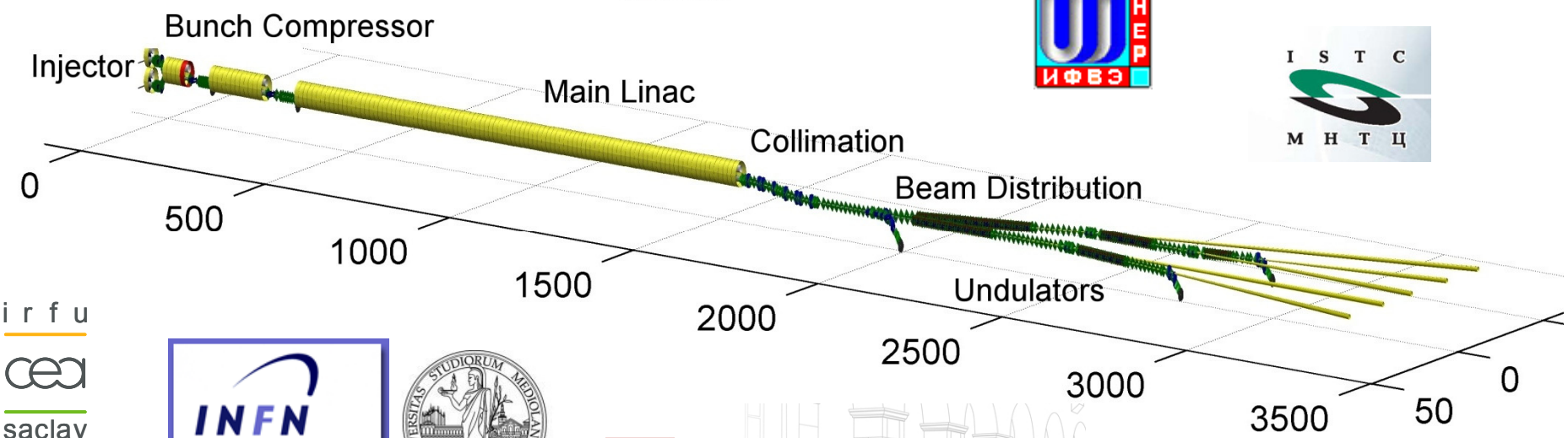


SRF13| Catherine MADEC

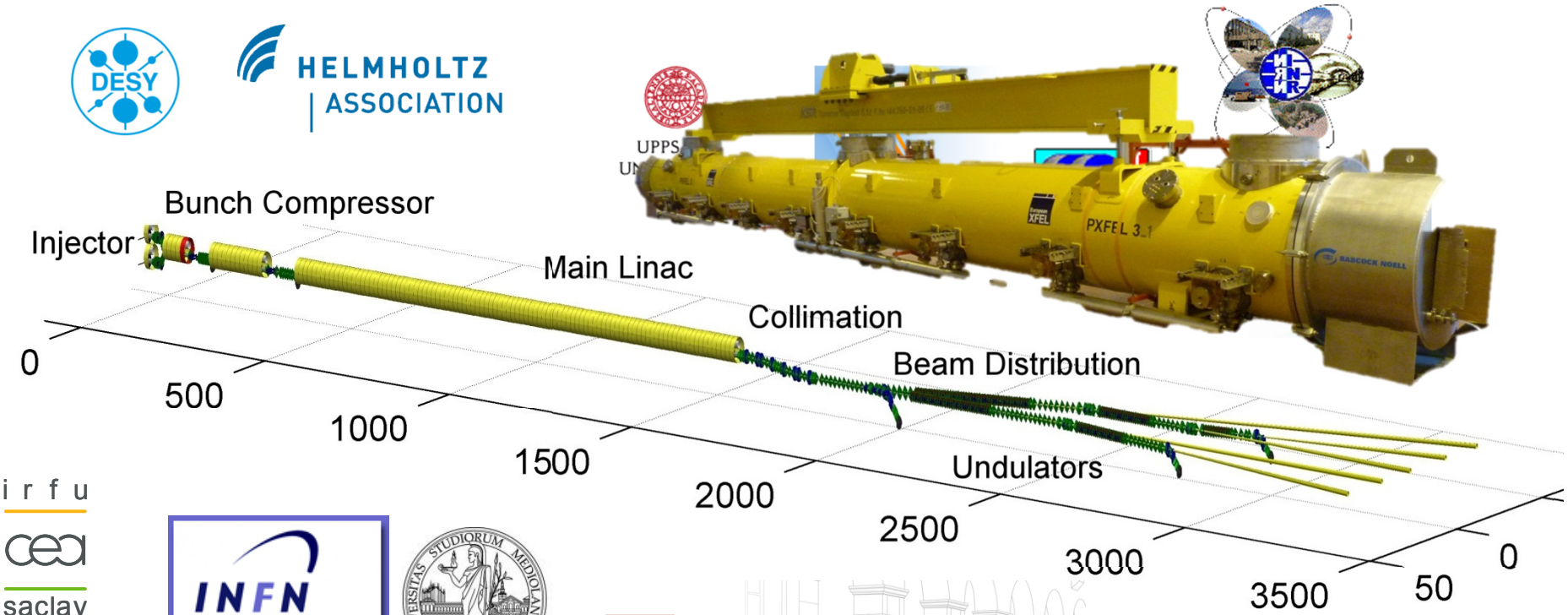
www.cea.fr

Irfu

QUICK OVERVIEW



QUICK OVERVIEW



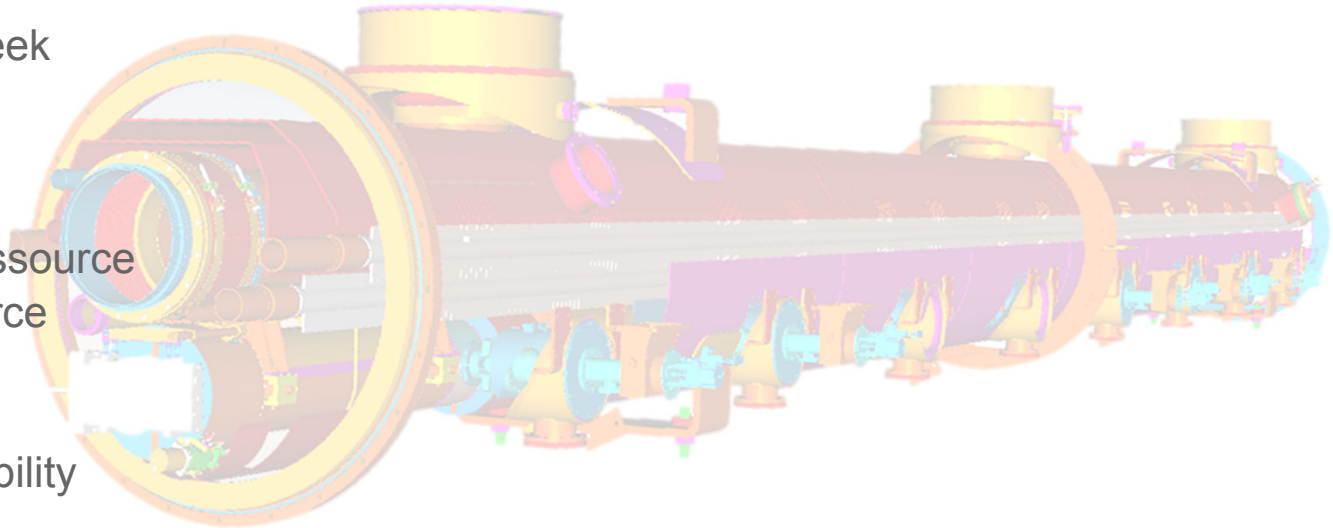
GOAL

To assemble **100** accelerator cryomodules with a **throughput of 1 per week** !

operated by an **industrial contractor** on the Saclay site and CEA infrastructures with CEA supervision

CHALLENGES

- Technical:
  - Get the infrastructure ready
  - Get the tooling ready
  - Get the assembly procedure ready
  - Get the CEA team trained
  - Get the quality insurance system implemented
  - Set-up QA/QC and MBOM
  - Get results
- Calendar:
  - 1 CM per week
  - Nov 2015
- Ressources :
  - Industrial ressource
  - CEA ressource
- Performances
- Components availability



PHASES OF THE PROJECT

1. Preliminary study subcontracted 2007 – 2008
2. Preparation of Infrastructure and Tooling 2009 – 2010
3. Pre-industrial study and prototyping 2010 – 2012
   - Preindustrial study
   - Training and Commissioning at Saclay with XFEL Prototype Modules (PXFEL2 and PXFEL3)

   ➢ Leading to Restricted Call for Tender signed in July 2012
4. XFEL module assembly by industry operator 2012 - 2015

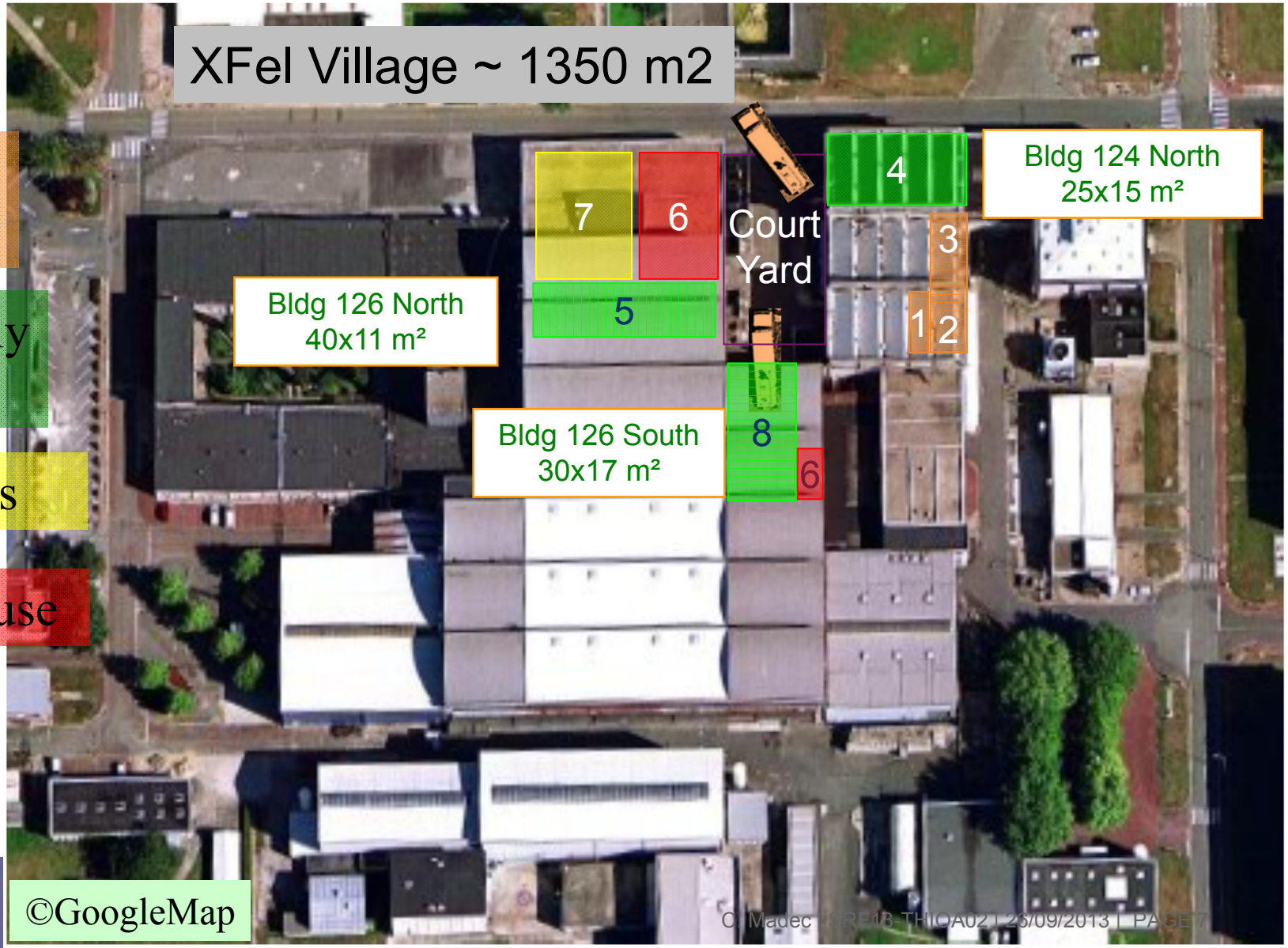
PHASE 2 : DEDICATED ASSEMBLY BUILDINGS

Clean rooms

Assembly halls

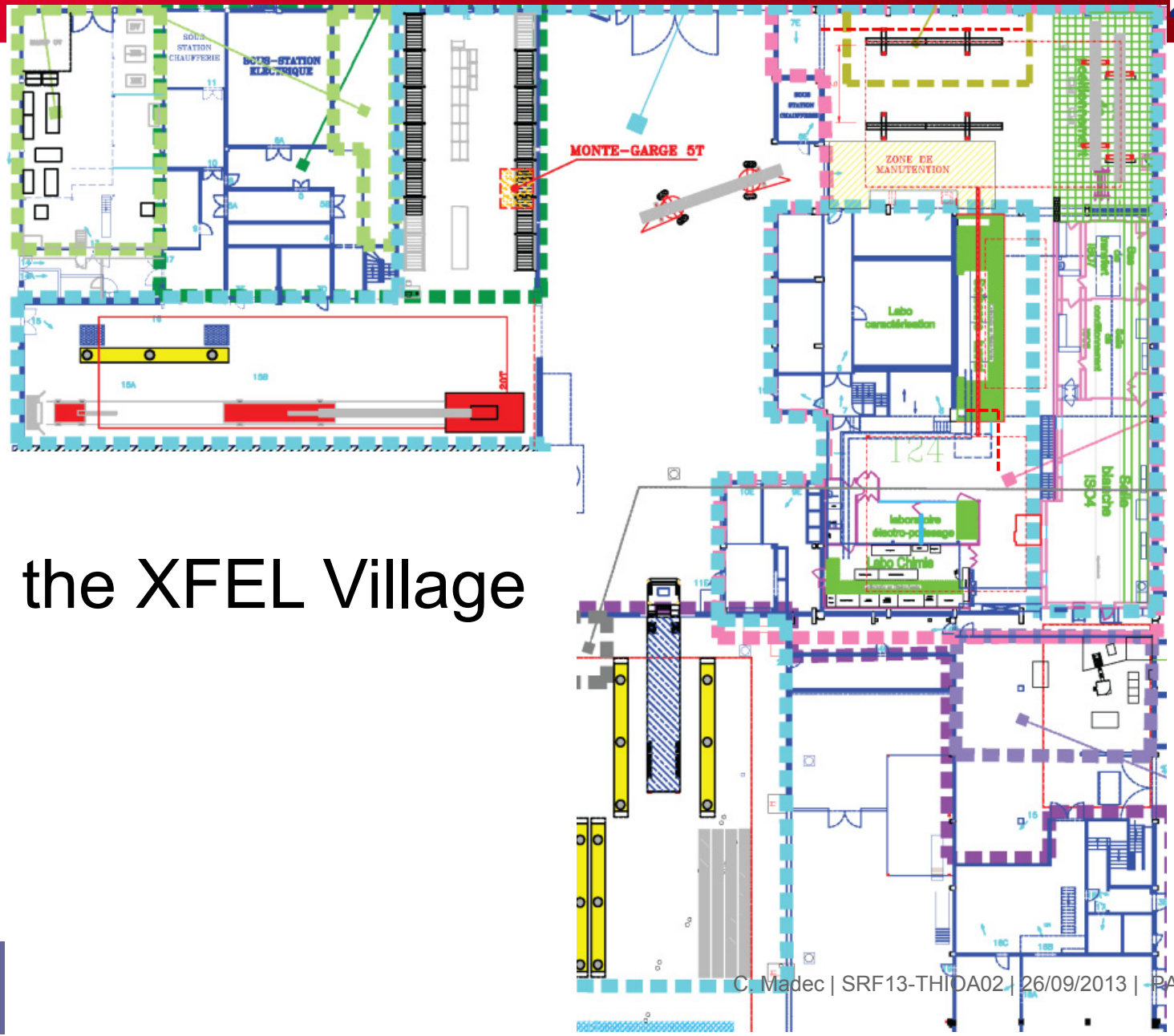
Offices

Warehouse



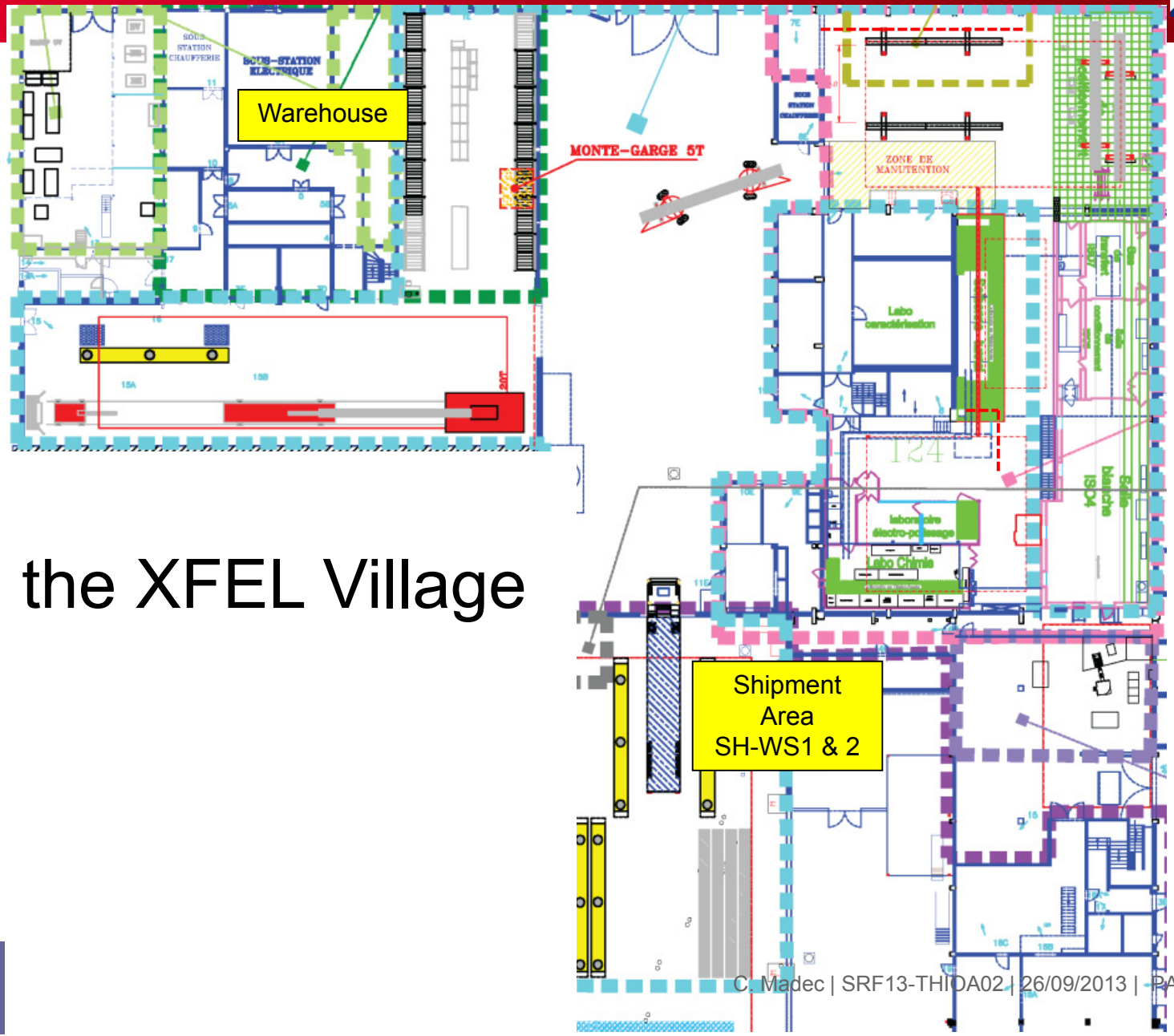
©GoogleMap

PHASE 2 : WORKSTATIONS IN ASSY HALLS



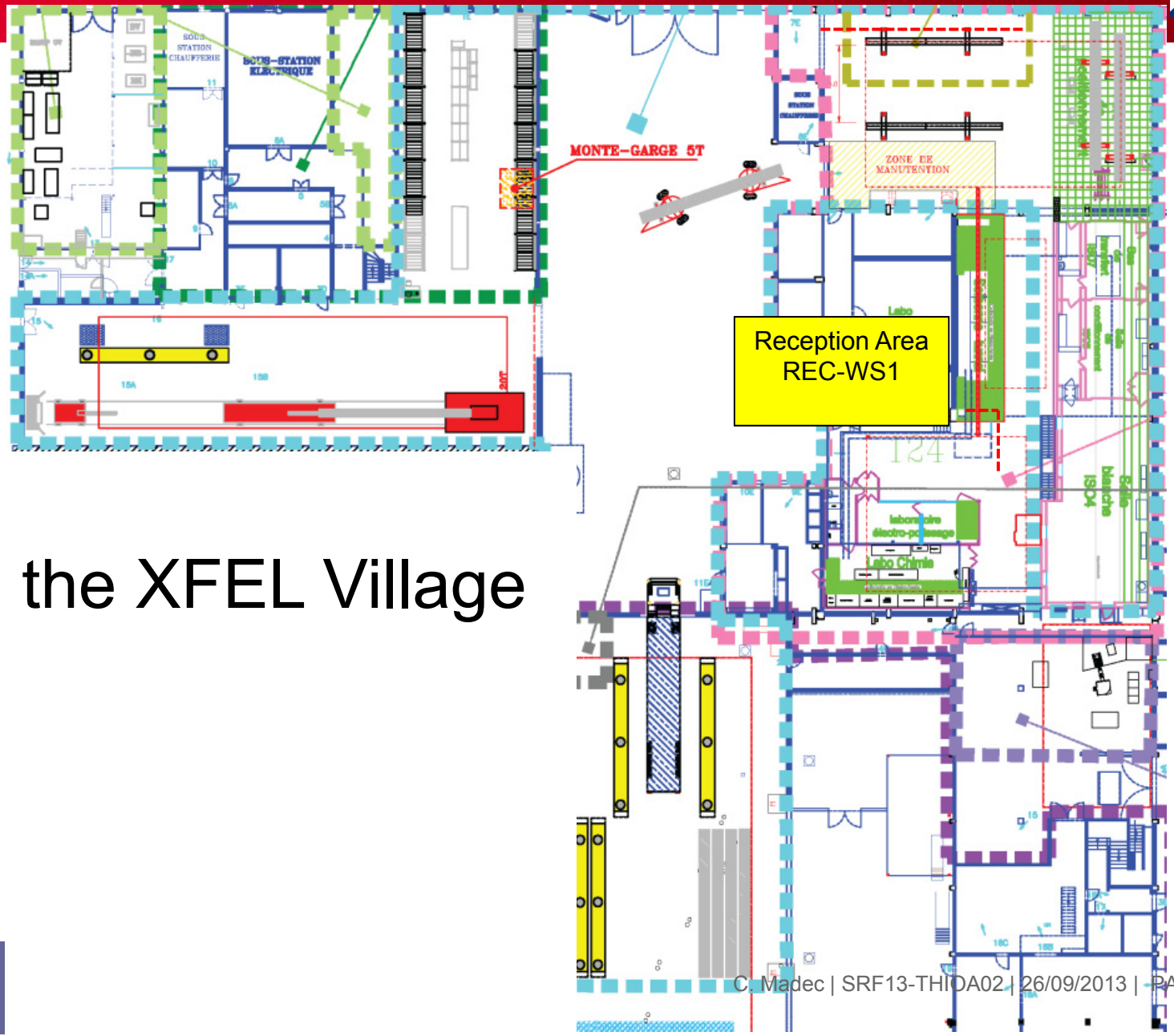
the XFEL Village

PHASE 2 : WORKSTATIONS IN ASSY HALLS



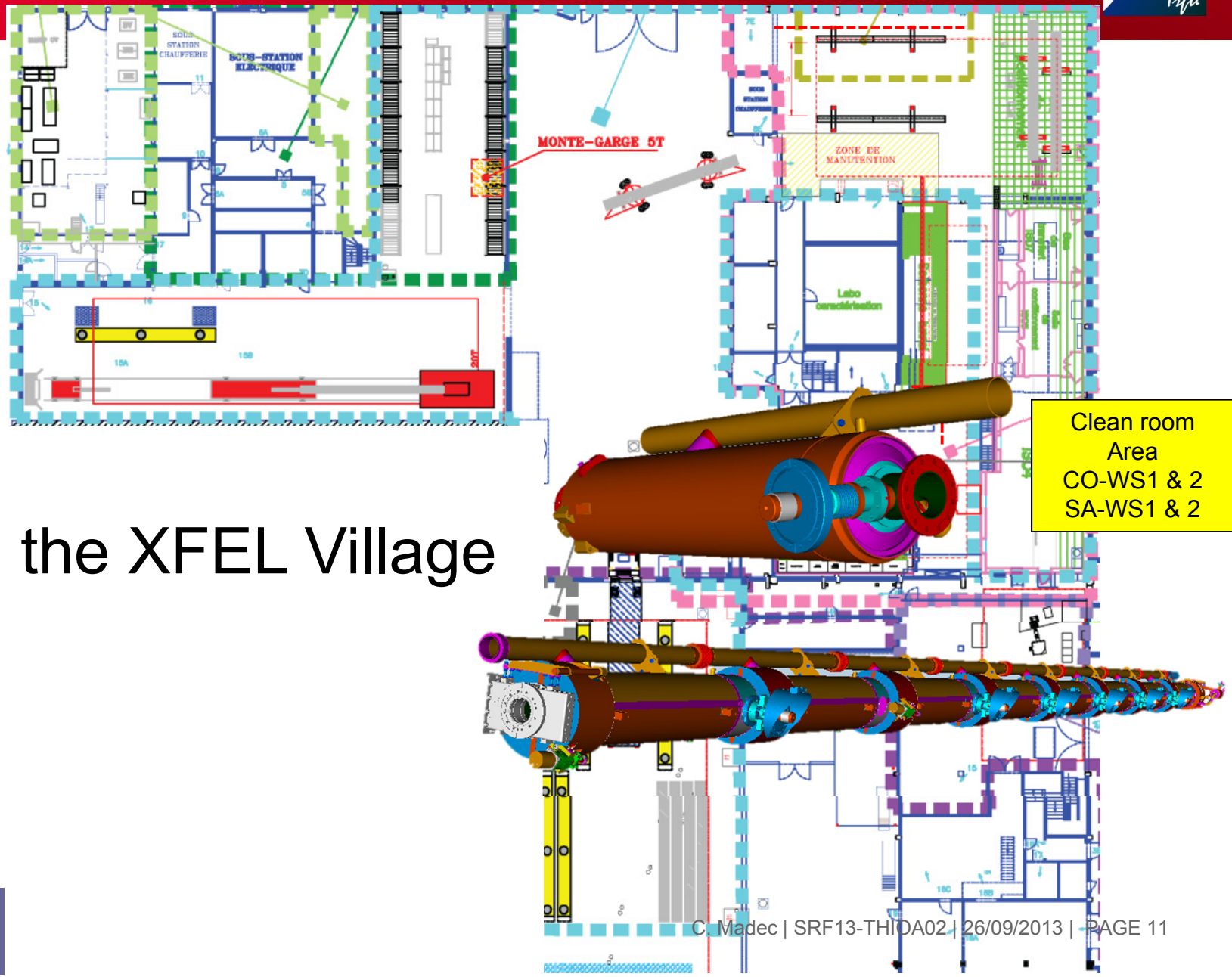
the XFEL Village

PHASE 2 : WORKSTATIONS IN ASSY HALLS



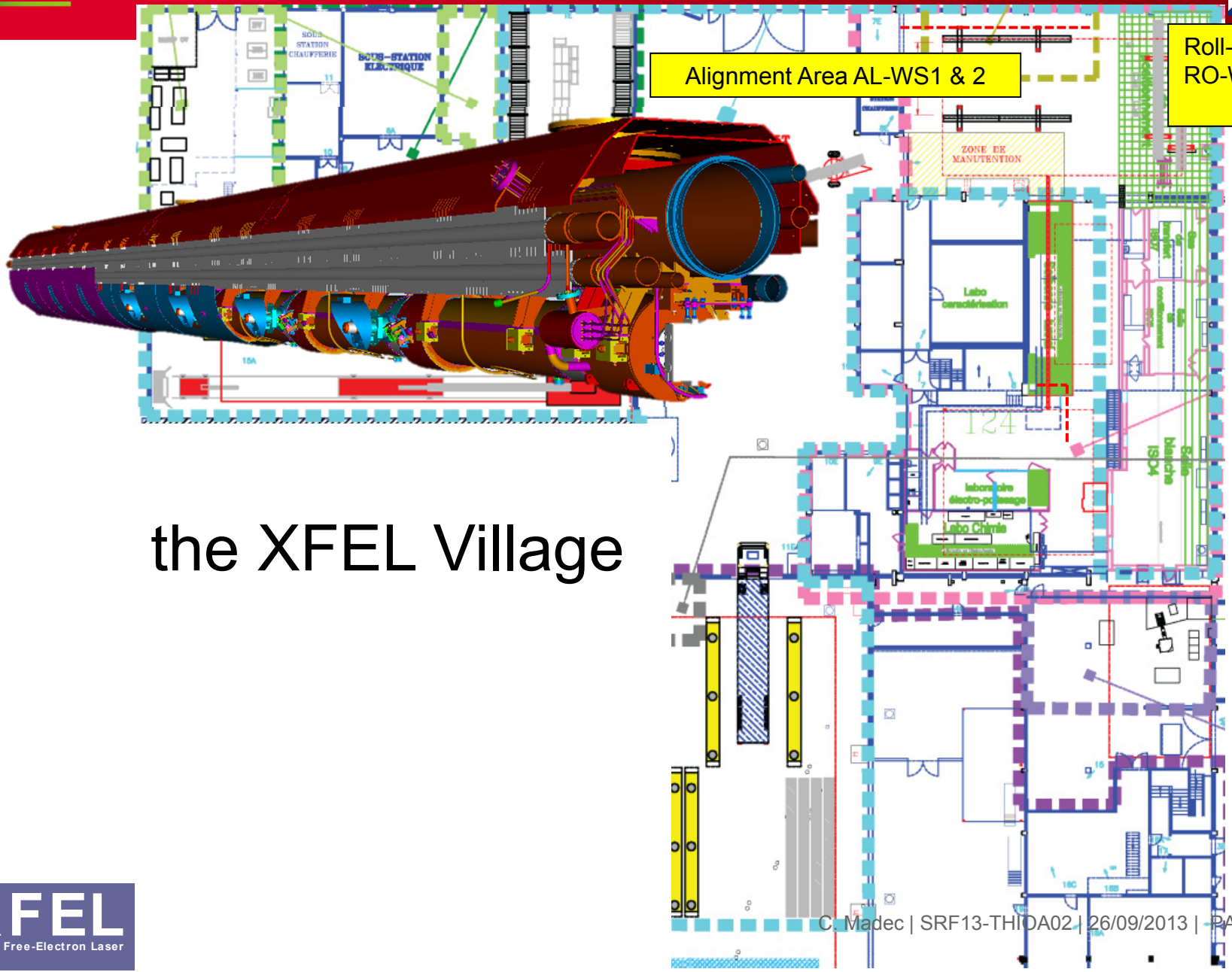
the XFEL Village

PHASE 2 : WORKSTATIONS IN ASSY HALLS



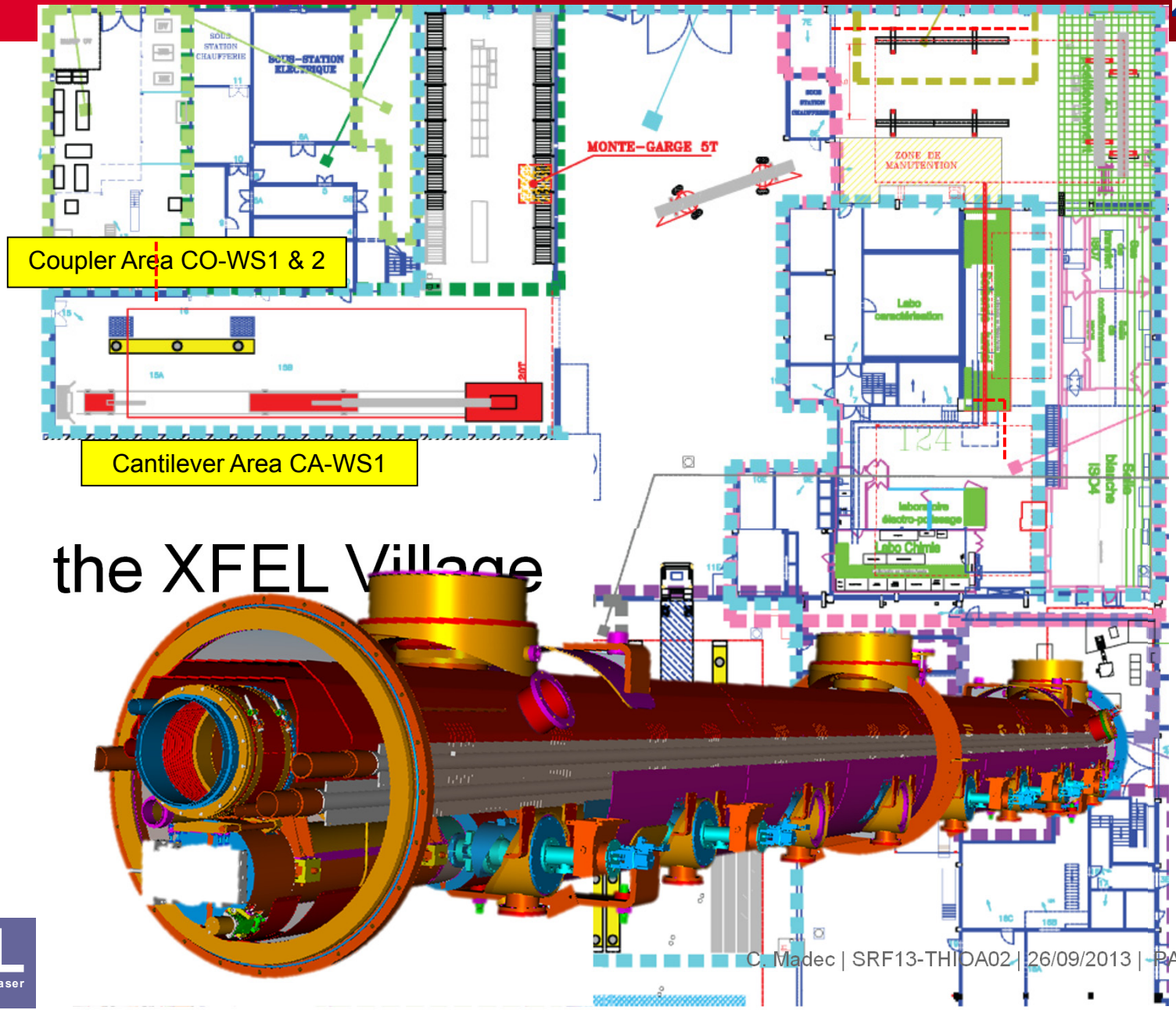
the XFEL Village

PHASE 2 : WORKSTATIONS IN ASSY HALLS

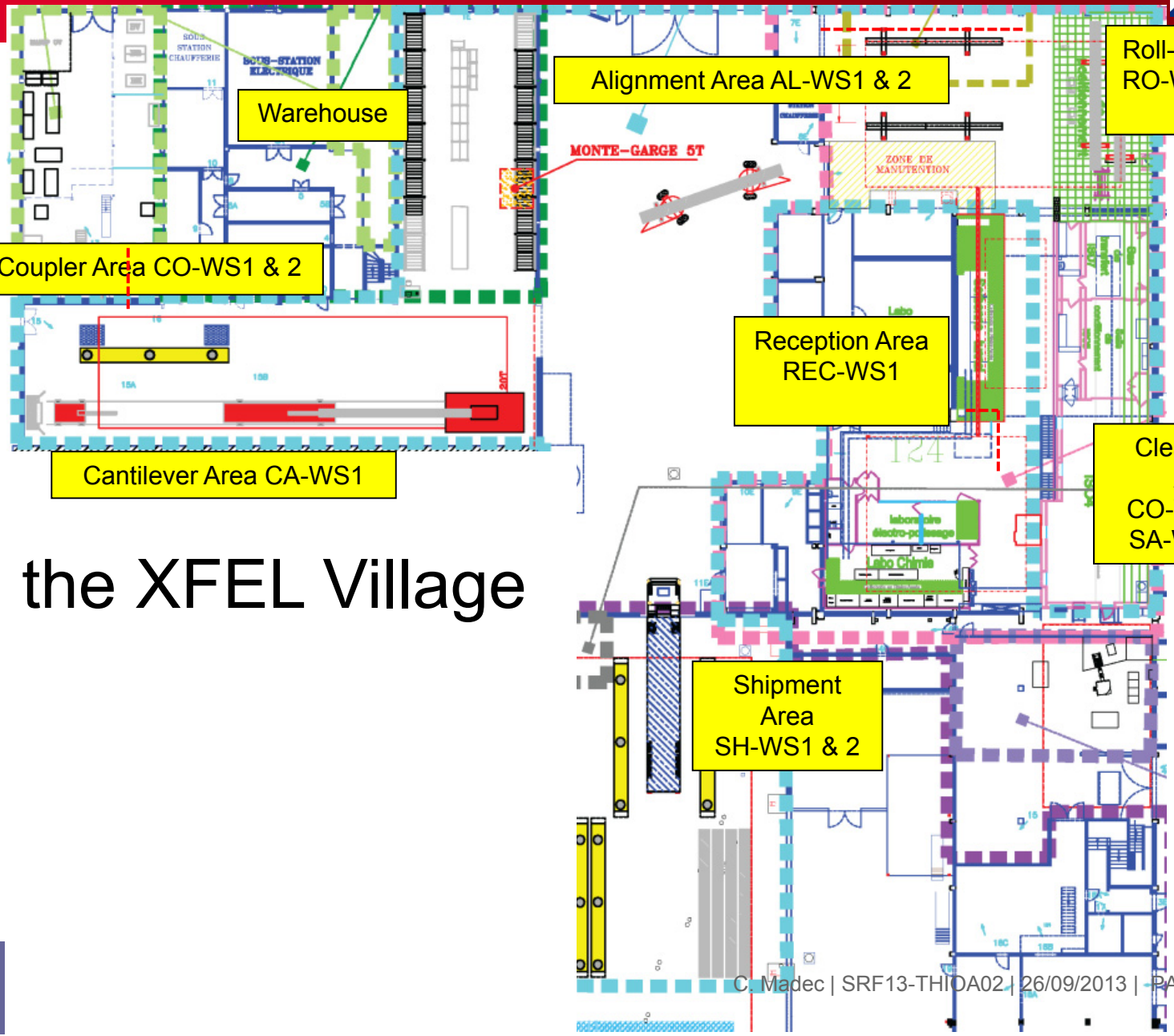


the XFEL Village

PHASE 2 : WORKSTATIONS IN ASSY HALLS



PHASE 2 : WORKSTATIONS IN ASSY HALLS



the XFEL Village

PHASE 2 : TOLLING, RENOVATION, CLEAN ROOM

PHASES OF THE PROJECT

1. Preliminary study subcontracted 2007 – 2008
2. Preparation of Infrastructure and Tooling 2009 – 2010
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   - Preindustrial study
   - Training and Commissioning at Saclay with XFEL Prototype Modules (PXFEL2 and PXFEL3)

   ➢ Leading to Restricted Call for Tender signed in July 2012
4. XFEL module assembly by industry operator 2012 - 2015

PHASE 3 : PROTOTYPING

GOAL : to get the « Factory » ready

- Implement the pre-industrial study
- Check the infrastructures
- Check the tools
- Check the procedures
- Train the CEA-IRFU team
- Prepare all the documentation templates
- Set-up the QA/QC and MBOM
- Feedback from the assemblies
- With the support of DESY coleagues

PHASE 3 : PROTOTYPING

The team (~10 persons) has operated :

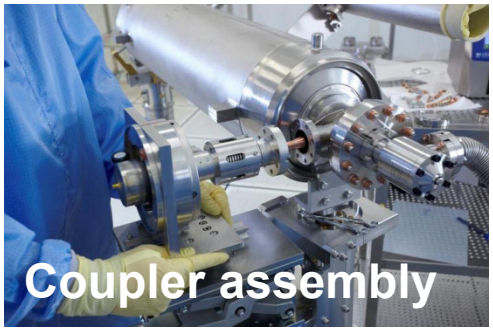
- the module disassembly of PXFEL2_1 (started 24/08/2010)
- the module re-assembly of PXFEL2_1
- the string and module assembly of PXFEL3_1 (02/05/2011 – 26/10/2011)

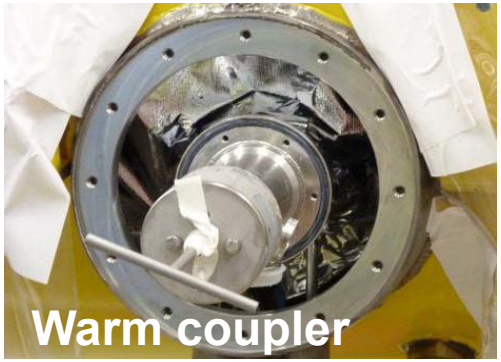
  using DESY cavity posts and clean room tools
- the string and module assembly of PXFEL2_2 (30/01/2012 – 04/09/2012)

  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…

PHASE 3 : PROTOTYPING



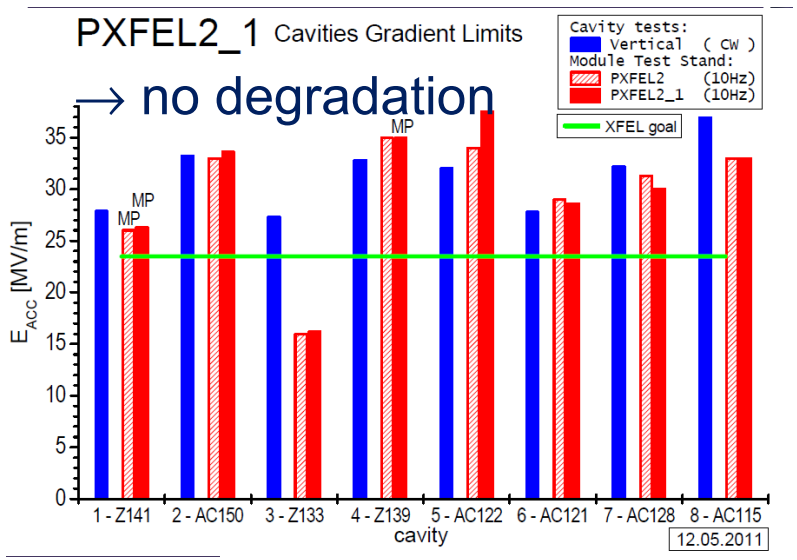


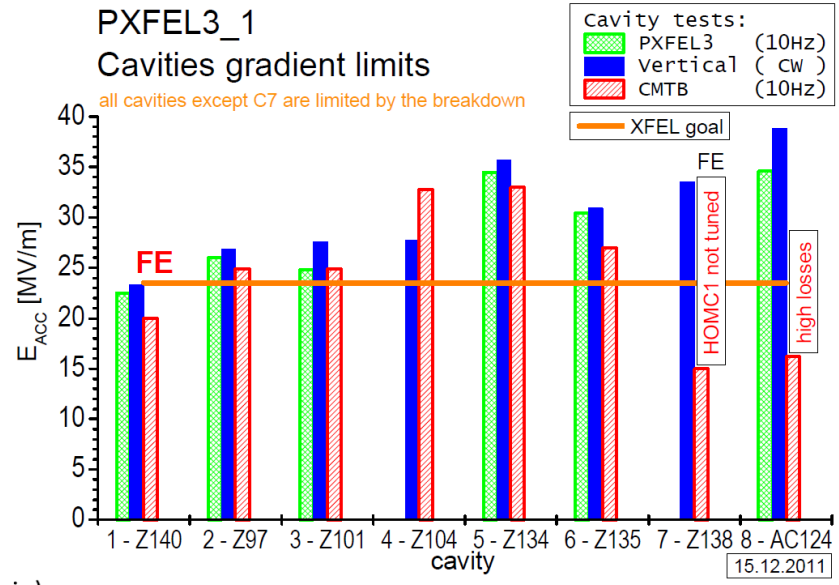
Check :

- ✓ Infrastructures
- ✓ Tools
- ✓ Procedures

CEA team trained

PROTOTYPES TEST RESULTS IN CMTB





Operating Gradient (Xray <= 10^{-2} mGy/min)

→ PXFEL2_2 ;

→ Average gradient ~ 24 MV/m , XFEL conform !

→ But individual performance were degraded

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

The MBOM also includes inspection to be performed, the tests to be recorded, the assembly procedures etc... The XFEL cryomodule MBOM contains roughly 500 lines

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

EXAMPLE : XM-2 MBOM

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. This is recorded in the Bill of Material

BOM

EXAMPLE : XM-2 BOM

Physical Part , D00000011111189,A,1,1 , Item Info : BOM

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

Configuration: No saved configuration.

Export Table As ◉ CSV ○ HTML ○ XML

EDMS-ID	Serial Number	Description	Work Status	Disposition Type	Installation Date/Time
D00000011111189,A,1,1	XM-2_CMAS	XM-2_CMAS: Cold Mass + Aligned String	Working (in Vault)		
D00000010985499,A,1,1	XM-2_CMS	XM-2_CMS: Cold Mass + String	Working (in Vault)		17.09.2013 16:14:45
D00000010958059,A,1,1	XM-2_STR	XM-2_STR: Cavity String	Released	In-Service	01.08.2013 10:31:53
D00000010978319,A,1,1	XM-2_SIN2K	SIN2K: Super Insulation 2K	Working (in Vault)		01.08.2013 16:01:59
D00000010845279,A,1,1	SET No 2	Cab-CAV: Cavity RF Cables	Released	In-Service	01.08.2013 11:53:55
D00000010520869,A,1,1	EZ004	CM: Cold Mass Assembly	Released	In-Service	01.08.2013 11:42:58
D00000010209329,A,1,1	3_08_9610/2.C00 #0002	2Ph Cav1 End Connect	Released	In-Service	31.07.2013 14:22:58
D00000010169569,A,1,1	3_06_8326/0.000 #0002	Cav1 Gate Valve Support	Released	In-Service	31.07.2013 14:23:01
D00000010178409,A,1,1	3_06_8322/0.000 #0014	Ti-Bellow DN76	Released	In-Service	31.07.2013 14:33:41
D00000010178389,A,1,1	3_06_8322/0.000 #0013	Ti-Bellow DN76	Released	In-Service	31.07.2013 14:42:36
D00000010178369,A,1,1	3_06_8322/0.000 #0012	Ti-Bellow DN76	Released	In-Service	31.07.2013 14:51:40
D00000010178349,A,1,1	3_06_8322/0.000 #0011	Ti-Bellow DN76	Released	In-Service	31.07.2013 15:00:45
D00000010178329,A,1,1	3_06_8322/0.000 #0010	Ti-Bellow DN76	Released	In-Service	31.07.2013 15:10:02
D00000010178309,A,1,1	3_06_8322/0.000 #0009	Ti-Bellow DN76	Released	In-Service	01.08.2013 11:07:35
D00000010178289,A,1,1	3_06_8322/0.000 #0008	Ti-Bellow DN76	Released	In-Service	01.08.2013 11:08:08

EXAMPLE : PHYSICAL PARTS

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

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

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

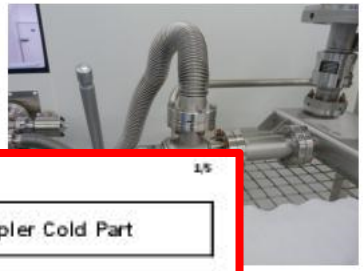
Properties

Description: XM-3_CCP:

old Part (TTF3)

Irfu | BOMs/ASS_CR_26 | V 5.1 | Coupler venting for coupler cold part assembly | Page 1/6 | Date : 22/03/2012

Coupler venting for coupler cold part assembly



Approved by	
Name	Catherine Madec
Function	Ingénieur Système Adjoint Chef de Projet
Date	
Signature	

1/5

Irfu | Incoming Inspection Report: Coupler Cold Part

1	General Information (for protocol upload)	
	Project	XFEL_WP03_Alsyom
	Team	XFEL_WP03_Alsyom_Team
	Team Folder	CEA_Templates
	Location	CEA XFEL Reception Area in ISO5 Cleanroom

2	Fabrication Part (FP) Information			
	Part	Fabr. Part Name	Fabr. Part EDMS ID	FP Acronym
	TWG	TTF3_TWG: Test Wave Guide	[illegible]	TTF3_TWG
	CCP Position 1	XM-3_CCP: Coupler Cold Part (TTF3)	[illegible]	XM-3_CCP
	CCP Position 2	XM-3_CCP: Coupler Cold Part (TTF3)	[illegible]	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-BGE	
	CCP Position 2	AC3C33	Research Instruments GmbH	DEU-RI-BGE	

4	Contact Information		
	Name_Firstname	Kaabi, Walid	Work Package
	Phone number		XFEL-WP03
	Email	kaabi@lal.in2p3.fr	

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

EXAMPLE : 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

Irfu / European XFEL	**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)

PHASES OF THE PROJECT

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   - Preindustrial study
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   ➢ Leading to Restricted Call for Tender signed in July 2012

4. XFEL module assembly by industry operator 2012 – 2015

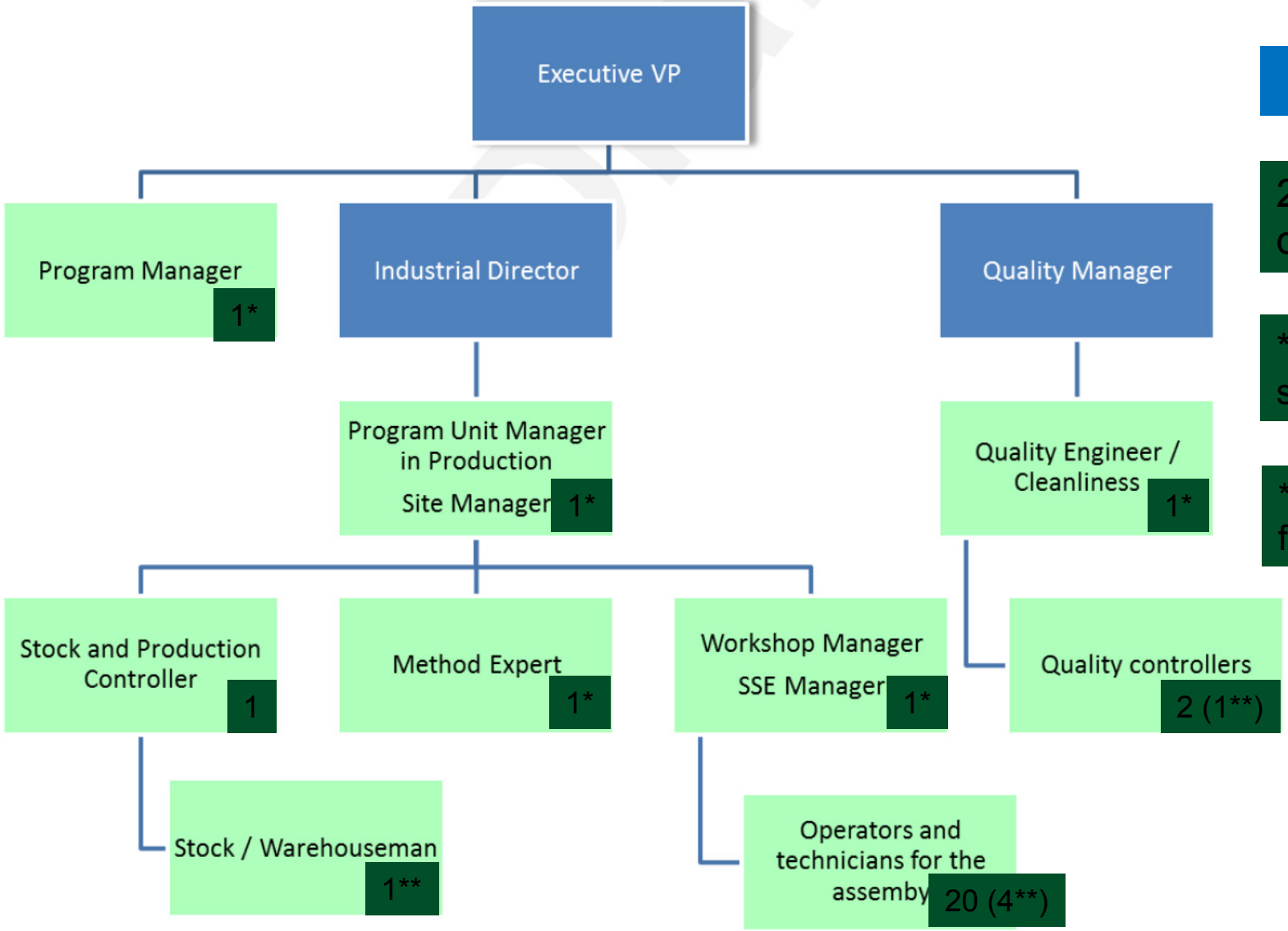
   Pre-serie modules : XM-3, XM-2, XM-1

   Serie module : XM1 to XM100

INDUSTRIAL CONTRACT : INTRODUCTION

- Tender process: ALSYOM, 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 one year, 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

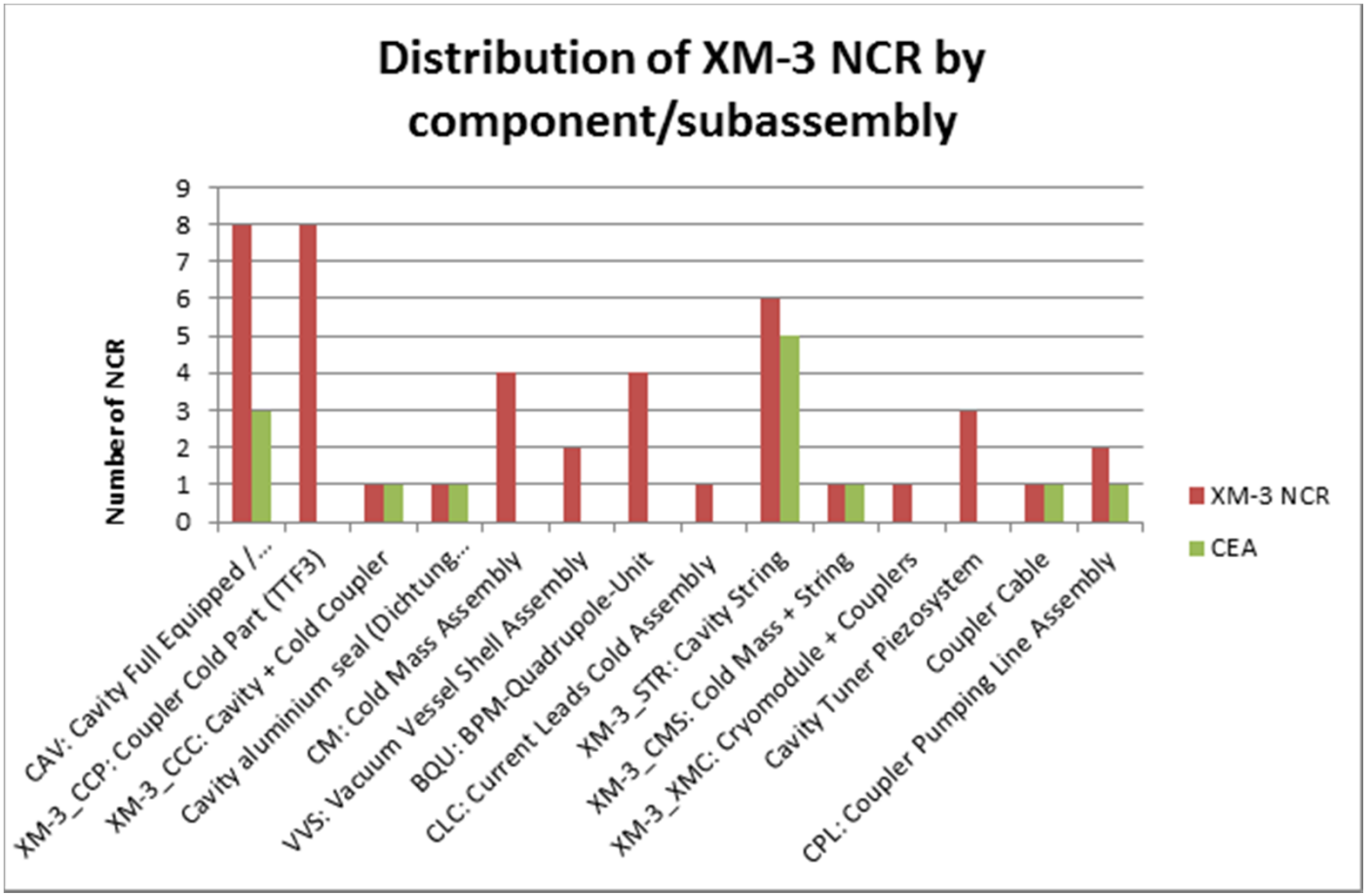
** from beg-febr. 2013

INDUSTRIAL CONTRACT : OBSERVATION PHASE

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). Extended to April 2013

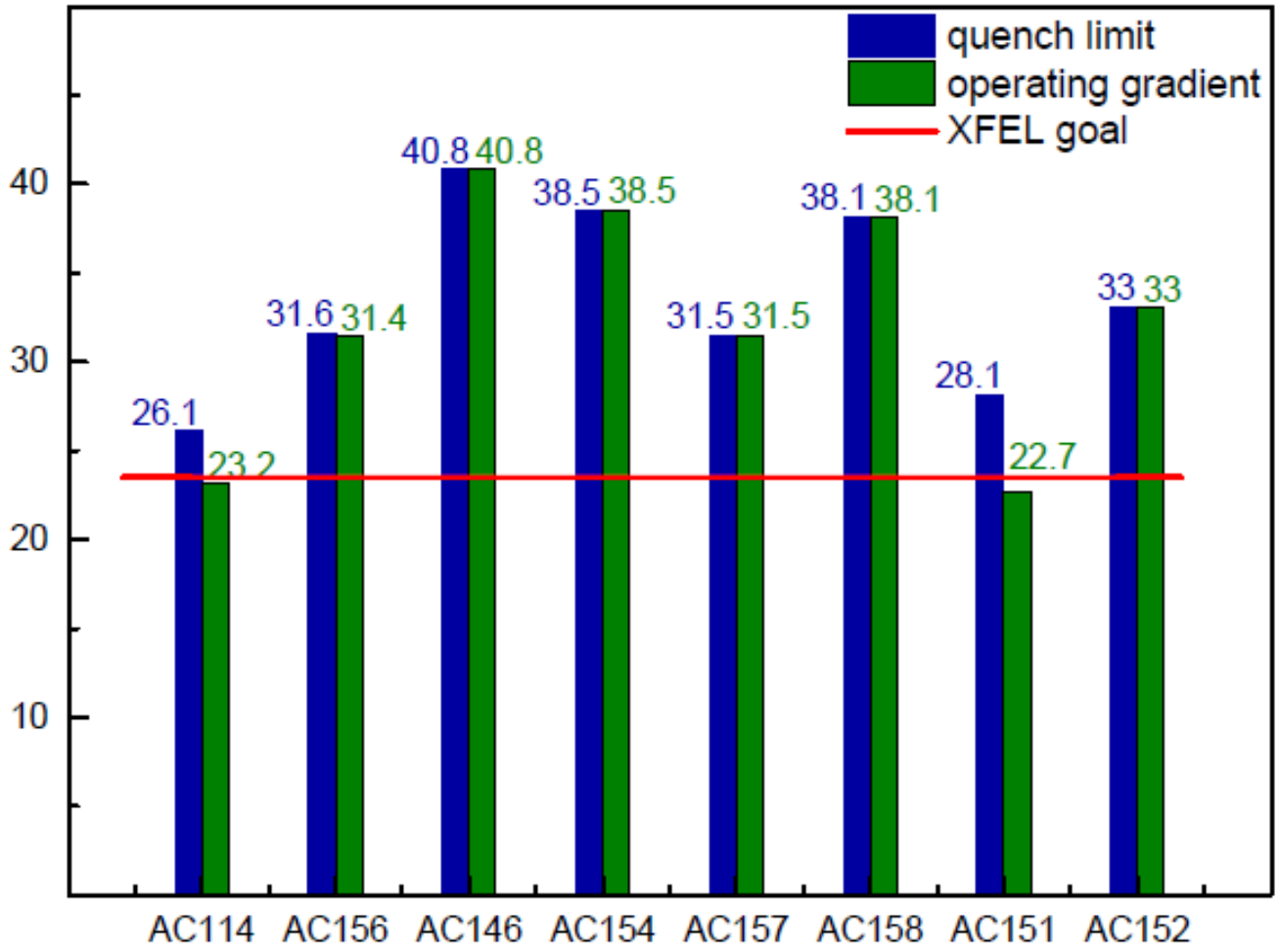
XM-3 first pre-series module is made with parts from XFEL production lines, except for cavities (large-grain RI cavities) and couplers (TTF3 RI couplers).

INDUSTRIAL CONTRACT : XM-3 NCR



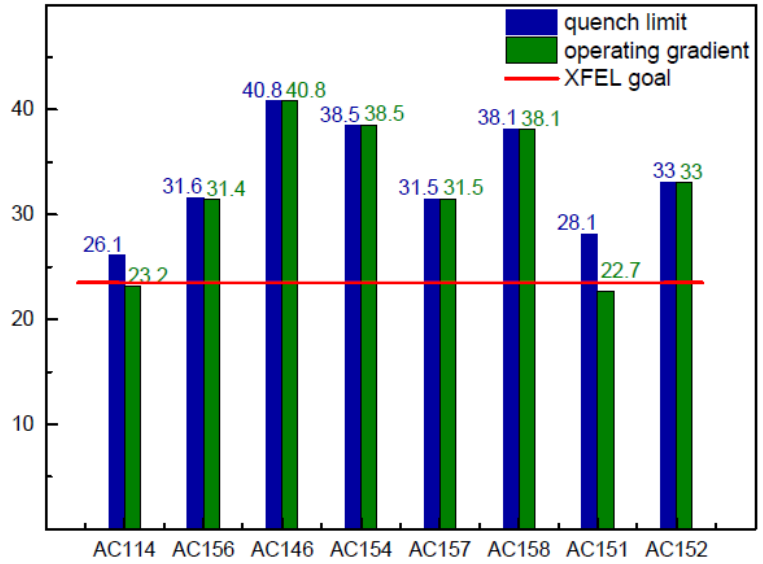
In total 43 Non-Conformance Reports (NCR) were issued for XM-3, some global, about 13 NCR under the responsibility of CEA: one main reason for 7 month assembly.

XM-3 TEST RESULTS



XM-3 TEST RESULTS

- ✓ Average individual cavity gradients reaches 32 MV/m
- ✓ Gradient is 29 MV/m when cavities are powered by pairs
- ✓ Seven cavities are reproducing VT gradient
- ✓ cavity 1 is degraded from 31 MV/m down to 23 MV/m useable gradient
- ✓ Three cavities reached gradients above 38 MV/m.
- ✓ Cryogenics losses are lower than specified (MOP029)
- ✓ This successful test is qualifying CEA team and procedures and partially CEA infrastructure and industrial feasibility.
- ✓ The partial qualification lays in the fact that cavities and couplers are pre-industrial and the clean room vacuum system was not complete.
- ✓ Weldings certification would have to be reworked in order to install this module in the injector for 2014.



INDUSTRIAL CONTRACT : TRAINING PHASE

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 was made with parts from XFEL production lines, e.g first eight EZ cavities, except for couplers (TTF3 RI couplers) ; 18 wks/14wks. XM-2 is at DESY getting ready for testing

XM-1 has started on August 2013 first pre-series module made with parts from XFEL production lines, including cavities and couplers; still under assembly

XM-2 NCR

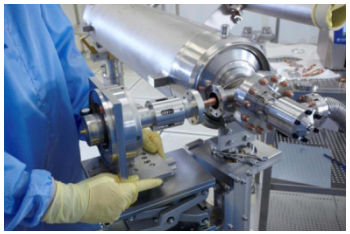
XM-2 NCR's									
NCR Reference	NCR EDMS ID	Ref cryomodule	Sub-assembly	Serial N°	Acronyme	WS	Origin	Detection	Description
CEA-XFEL-RNC-12-047	D*1019155	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C43, AC3C44, TWG012	CCP	REC	PRODUCT	PRODUCTION	Bad position of screws on ceramic protection cap + Presence of water inside cold ceramic cap
CEA-XFEL-RNC-12-077	D*1024275	XM-2	Cavity fully equipped	CAV00512	CAV_FE	REC	PRODUCT	PRODUCTION	Threaded rods too long on cavity beamtube adapter flange - short side
CEA-XFEL-RNC-12-081	D*1024345	XM-2	Cavity fully equipped	CAV00510	CAV_FE	REC	PRODUCT	PRODUCTION	High Q Antenna flange misoriented
CEA-XFEL-RNC-12-082	D*1024395	XM-2	Cavity fully equipped	CAV00510	CAV_FE	REC	PRODUCT	PRODUCTION	Cavity elbow valve mispositionned
CEA-XFEL-RNC-12-083	D*1024465	XM-2	Cavity fully equipped	CAV00509 & CAV00512	CAV_FE	SUP	PROCESS	PRODUCTION	Water entered inside 2Ph He pipe and tank during washing operation in the Belimed
CEA-XFEL-RNC-12-085	D*1024985	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C45 & AC3C47	CCP	REC	PRODUCT	PRODUCTION	Protective plastic bags are damaged (holes)
CEA-XFEL-RNC-12-086	D*1025055	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C45 & AC3C47	CCP	REC	PRODUCT	PRODUCTION	Valve on the cold ceramic cap misoriented
CEA-XFEL-RNC-12-087	D*1025115	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C45 & AC3C47	CCP	REC	PRODUCT	PRODUCTION	Connectors on the cold ceramic caps not properly screwed
CEA-XFEL-RNC-12-089	D*1025245	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C48 & AC3C50	CCP	REC	PRODUCT	PRODUCTION	Stainless steel screws on cold ceramic caps of the coupler
CEA-XFEL-RNC-12-090	D*1025305	XM-2	Cavity fully equipped	CAV00510 & CAV00514	CAV_FE	CC	PROCESS	PRODUCTION	Water inside cavity elbow valve
CEA-XFEL-RNC-12-090	D*1024545	XM-2	BQU: BPM Quadrupole Unit	BQU 002_C	BQU	REC	PRODUCT	PRODUCTION	Residual pressure of 2 10-2 mbar was read from the two PKR 261 gauges
CEA-XFEL-RNC-12-088	D*1025185	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C30 & AC3C31	CCP	REC	PRODUCT	PRODUCTION	Fingerprints and dust on the TWG
CEA-XFEL-RNC-12-092	D*1025365	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C30 & AC3C31	CCP	REC	PRODUCT	PRODUCTION	Coupler bellow clamps in contact with pick-up flange
CEA-XFEL-RNC-12-093	D*1025605	XM-2	Warm up tube	E2004	CM	AL	PROCESS	PRODUCTION	E20004 warm-up pipe damaged
CEA-XFEL-RNC-12-094	D*1025725	XM-2	Cavity fully equipped	CAV00509, CAV00510, CAv00513, CAV00514, CAV00526.	CAV_FE	REC	PRODUCT	PRODUCTION	Five cavities are out RF-measurement acceptance regarding the HOM RF rejection criteria
CEA-XFEL-RNC-12-095	D*1025855	XM-2	XM-3_CCP: Coupler Cold Part (TTF3)	AC3C31	CCP	CC	PRODUCT	PRODUCTION	Light scratches on the antenna of the cold part
CEA-XFEL-RNC-12-096	D*1025775	XM-2	Cavity fully equipped	CAV00509	CAV_FE	SA	PRODUCT	PRODUCTION	Presence of visible particules inside beam tube
CEA-XFEL-RNC-12-097	D*1025435	XM-2	Cavity fully equipped	CAV00523	CAV_FE	REC	PRODUCT	PRODUCTION	High Q Antenna flange and Cavity flange (Long side) misoriented
CEA-XFEL-RNC-12-098	D*1025495	XM-2	Cavity fully equipped	CAV00513	CAV_FE	REC	PRODUCT	PRODUCTION	Flange of elbow valve is dirty
CEA-XFEL-RNC-12-099	D*1027325	XM-2	Cavity fully equipped	ALL CAVITIES	CAV_FE	SA	PROCESS	PRODUCTION	Quick Cavity venting up to 6 mbar
CEA-XFEL-RNC-12-100	D*1025555	XM-2	CBL: Cavity Bellows	FEL VBI 000004-043	CBL	SA	PRODUCT	PRODUCTION	Marks on inside waves of the cavity bellow
CEA-XFEL-RNC-12-101	D*1025915	XM-2	BQU: BPM Quadrupole Unit	BQU 005_C	BQU	REC	PRODUCT	PRODUCTION	Residual pressure of 2 10-2 mbar was read from the two PKR 261 gauges
CEA-XFEL-RNC-12-102	D*1027265	XM-2	Needle Support assembly (type 1 and 2)	E2004		RO	PRODUCT	PRODUCTION	Metalic chips in threads of needle supports
CEA-XFEL-RNC-12-103	D*1027445	XM-2	Cavity bellows	Cavites 7 et 8	CBL	RO	PROCESS	PRODUCTION	Chocs on CBL of cavities 7 et 8
CEA-XFEL-RNC-12-107	D*1027505	XM-2	PT1000 sensor		TMP-PT	AL	PROCESS	PRODUCTION	70K interface screw in contact with the sensor
CEA-XFEL-RNC-12-111	PP not created in EDMS	XM-2	XM-3_CWP: Coupler Warm Part (TTF3)	AC3H42	XM-3_CWP	CO	PRODUCT	PRODUCTION	M5 screw antenna seized in the warm part
CEA-XFEL-RNC-12-112	D*1026715	XM-2	Actuator Assembly (TTF3)	THRI-AC-002, 004, 010, 016, 019, 022	ACT	CO	PRODUCT	PRODUCTION	THRI-AC-002/THRI-AC-016/THRI-AC-019
CEA-XFEL-RNC-12-113	PP not created in EDMS	XM-2	XM-3_CWP: Coupler Warm Part (TTF3)	AC3H34	XM-3_CWP	CO	PRODUCT	PRODUCTION	Copper Plater missing on the outer conductor of the Warm Part
CEA-XFEL-RNC-12-115	PP not created in EDMS	XM-2	Capacitor Assembly (TTF3)	CP3K51 and CP3K53		CO	PRODUCT	PRODUCTION	Mechanical choc on capacitor CP3K51 and Mark of electrical flash on CP3K53
CEA-XFEL-RNC-12-116	D*1027265	XM-2	CLW: Current Leads Warm Assembly	003	CLW	CO			
CEA-XFEL-RNC-12-117	PP not created in EDMS	XM-2	Cryomodule	XM-2	XM-2	CO	TOOLING	PRODUCTION	Quick pumping of cavity string

NOTA: For Physical Parts not released in EDMS, the NCRs cannot be uploaded in the system.

02/08/2013

30's NCR
Decreasing number

INDUSTRIAL CONTRACT : RAMP-UP IN PRODUCTION PHASE

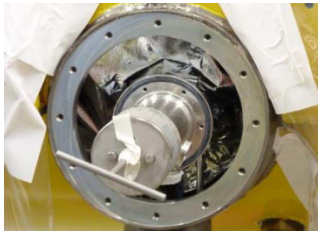


7 assembly area +1
=> 8 weeks of assembly

Ramp-up : XM1 to XM8 : 2 weeks per area
=> 16 weeks

Ramp-up from Sept. 2013 to Dec. 2013

Production : Dec. 2013 on



INDUSTRIAL CONTRACT : PRODUCTION PHASE

Production phase which covers the assembly of XM1 to XM80 by Alsyom from T2 = T0 + 9 months (September 2nd 2013) till T2 + 24 months (20 May 2015).

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).

Le futur est toujours beau …..
…. Le présent est difficile

Future is always beautiful…..
…. Present is tough

Commissariat à l'énergie atomique et aux énergies alternatives
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DSM
Irfu
SACM
LIDC2

BACK UP SLIDES

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

26/09/2013

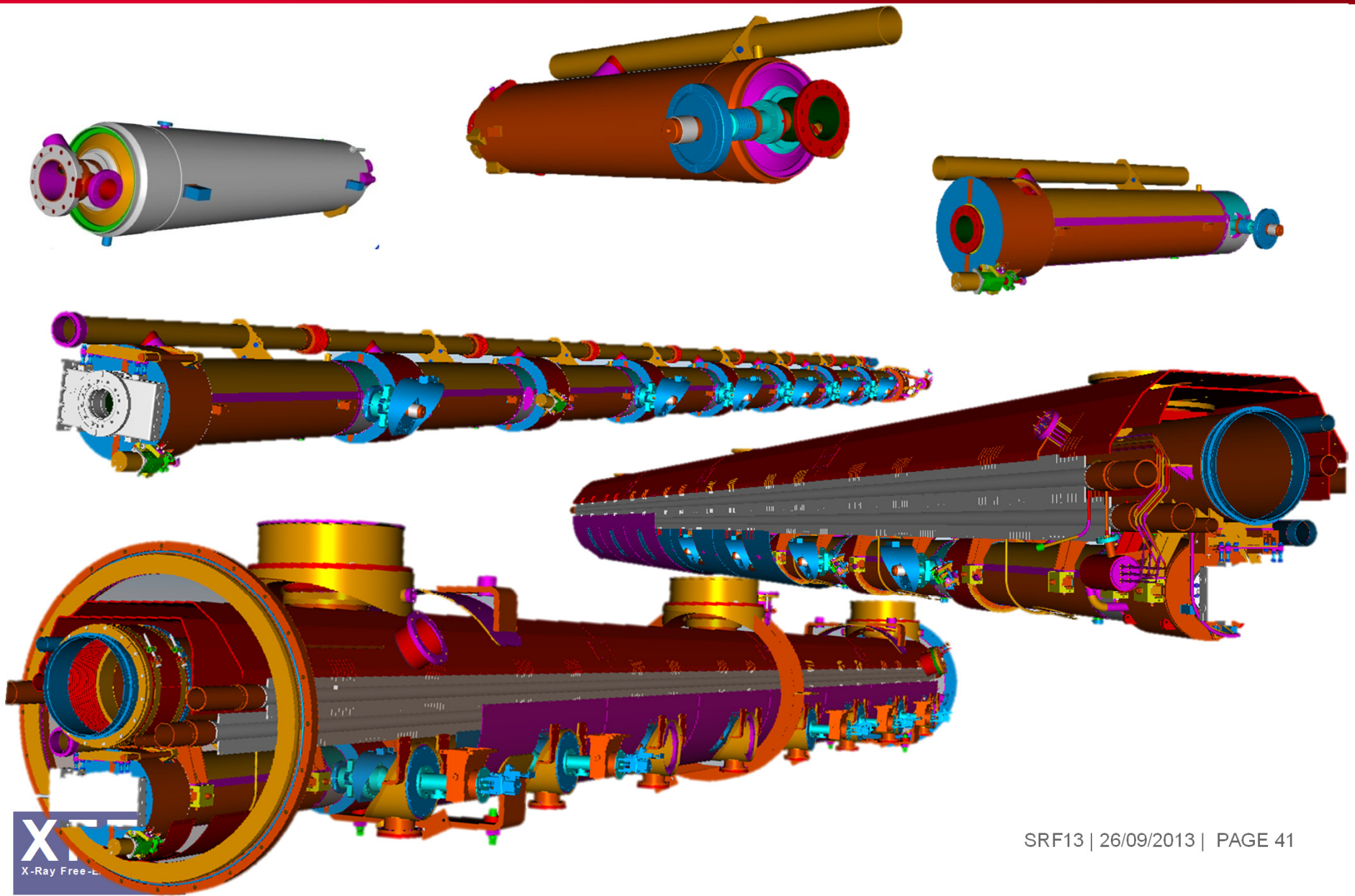
@	CfT	Kick-off	Prod
• Infrastructure and Tooling	80%	90%	100%
(in the broad sense, e.g. cavity supports)			
• Cryomodule Configuration	70%	85%	100%
• Cryomodule Documentation			
– PBS (or MBOM)	30%	70%	100%
– Availability of Drawings	30%	70%	100%
• Assembly Documentation (WBS)			
– Availabitity of Assembly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

Ratios are 100 % (cf. cavity production, or AMTF).

Industry start production with 100% of Input Data in their Resource Planning software (ERP)

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

ASSEMBLY STEPS



PRE-SERIES TRAINING PHASE: INITIAL SCHEDULE (1/3 BIS)

•Couplers NonConformity

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 sulfamic 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

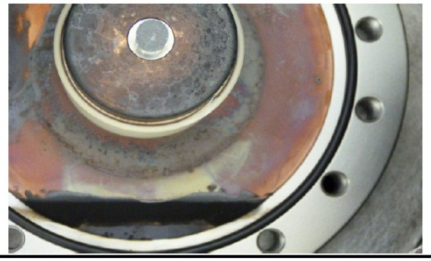
CATEGORY :		**FINAL DECISIONS :**	
Minor :		Action on Part :	Repair
Major :	X	Documentation :	

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

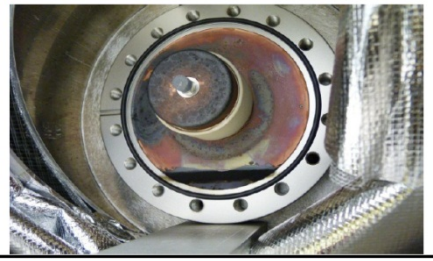
Irfu / European XFEL	NON CONFORMANCE REPORT	Reference :	CEA-XFEL-RNC-13-073
		Page :	2
		Date :	19.03.2013

CONTINUATION SHEET

Picture n°1



Picture n°2



XFEL
X-Ray Free-Electron Laser

PRE-SERIES TRAINING PHASE: INITIAL SCHEDULE (1/3 BIS)

•Alignment CEA Procedure Non Conformity

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

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

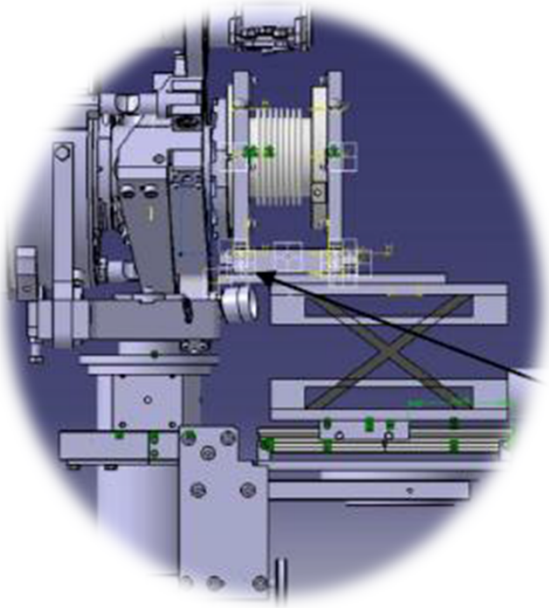
Group To Group Relationship
Groups: Koppler to Koppler (Reported in Nominalwerte: Modul)

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.

PHASE 3 : PRE-INDUSTRIAL STUDY

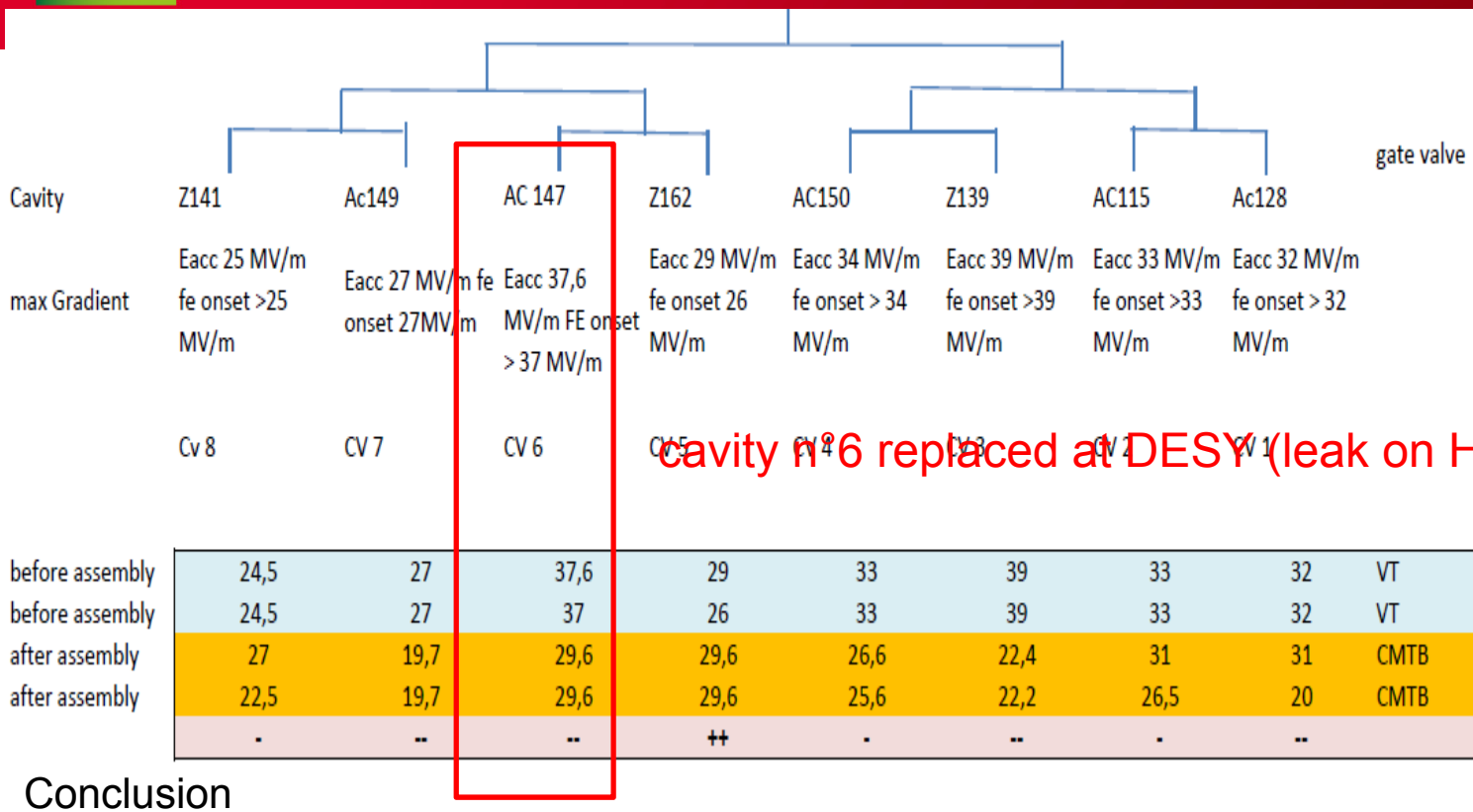
Ajilon was subcontracted to perform the pre-industrial study with the achieved goal of :



- Tools definition
- Assembly Procedures with the non mechanical operations
- Schedule
- PBS – EBOM
- Risk Analysis
- Interruption Scenarios
- Inventory Management
- List and implantation of Services and Fluid Distribution
- Listing of Parts and Its Packaging
- Description of Reception Process & Controls

- Using experience gained at DESY

PXFEL2_2 RESULTS



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

											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
	-	--	--	++	-	--	-	--				

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.

INDUSTRIAL CONTRACT : NCR

•Cavities Non Conformity

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

EQUIPMENT:	CAVITY	SERIAL NUMBER:	XM-3	FILLED OUT BY:	
Occurrence phase :				**Integration level :**	**Workstatio**
Control :		Reception :		Part	X
Manufacturing :		Acceptance :		Subassembly	
Design/validation :		Destockage :		Equipment	
Integration :	x	Others :		Others	

Reception Ha

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) :**

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.

PREVENTIVE ACTIONS (further item) : **Responsible (s) :**

Check of the helium tank dimensions for the industrially produced cavities.

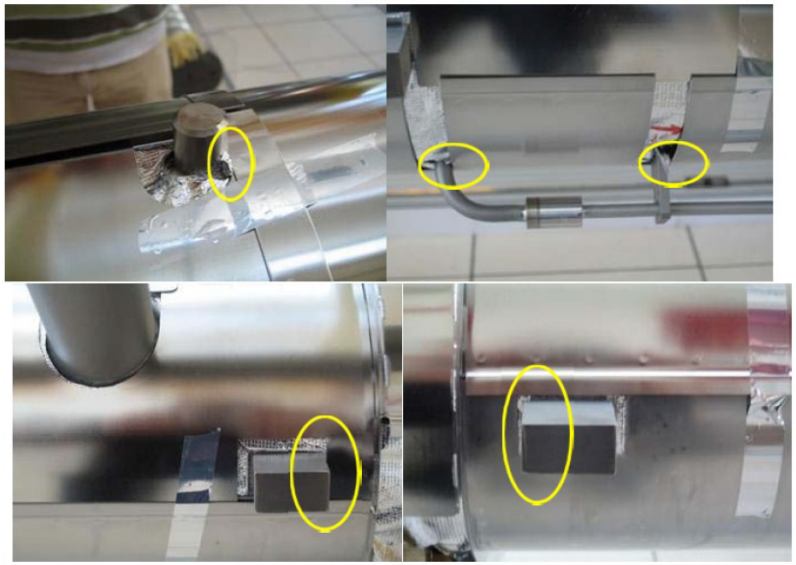
CLASS :
MINOR :
MAJOR :
FINAL DECISIONS :
USE AS IS
WAIVER
REPAIR
DOCUMENTATION CHANGE
SCRAP
MODIFICATION
ACTION ON OTHER PRODUCT

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

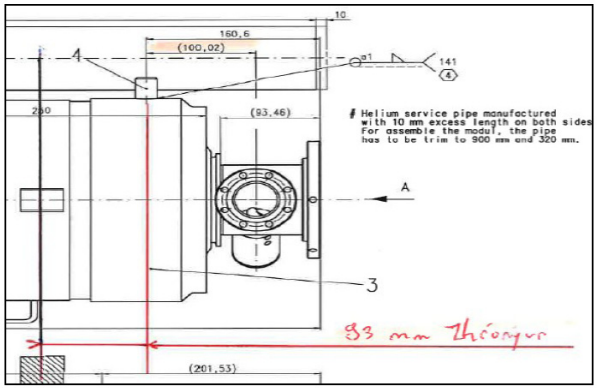
Irfu / European XFEL	NON CONFORMANCE REPORT / CHANGE REQUEST	Reference	CEA-XFEL
		Page	2
		Date	23/10/12

CONTINUATION SHEET

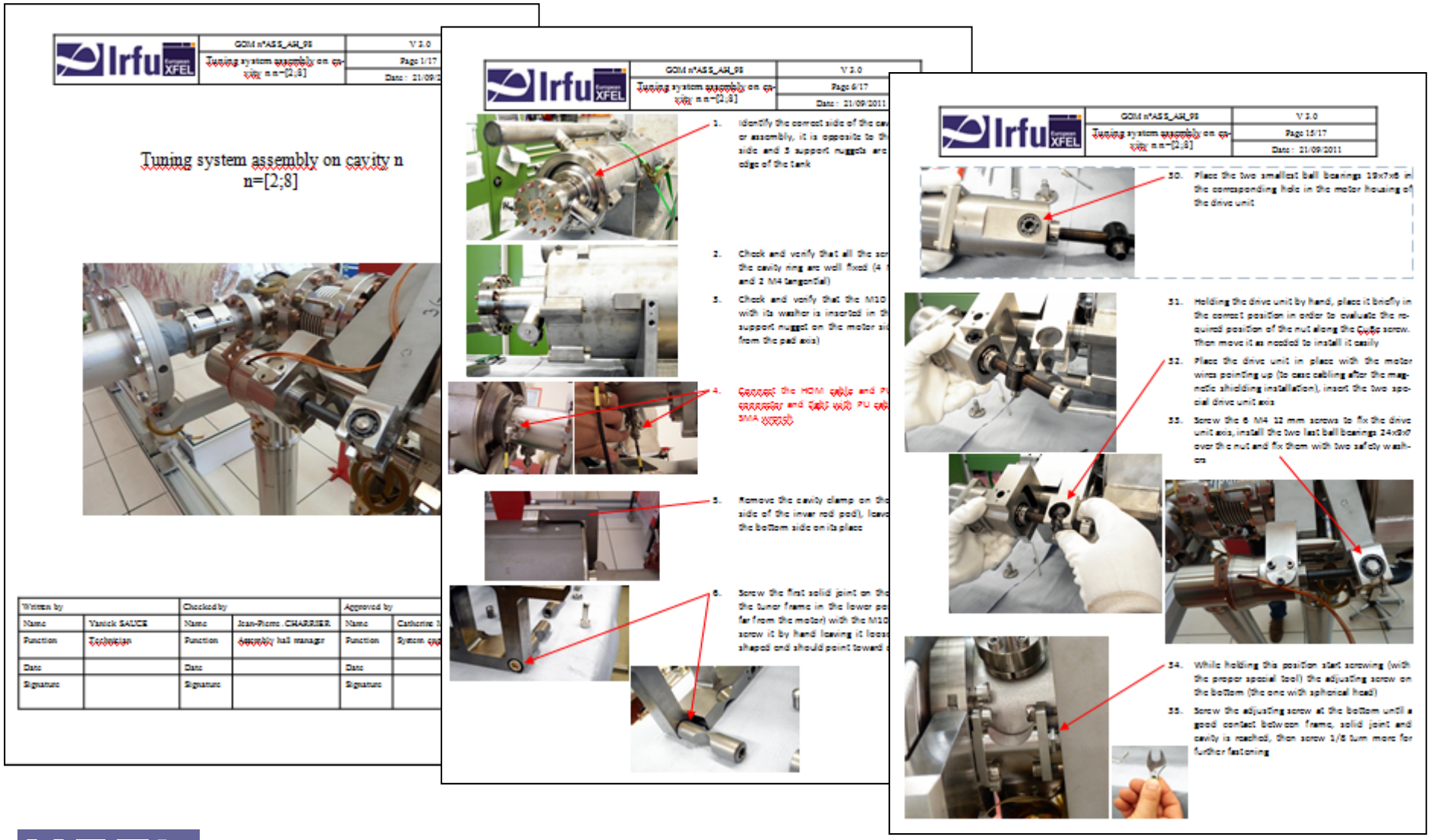
Assembly of the magnetic shield on the cavity AC158 :



Cavity drawing :



PHASE 3 : OUTPUT OF PRE-INDSUTRIAL STUDY ASSEMBLY PROCEDURES

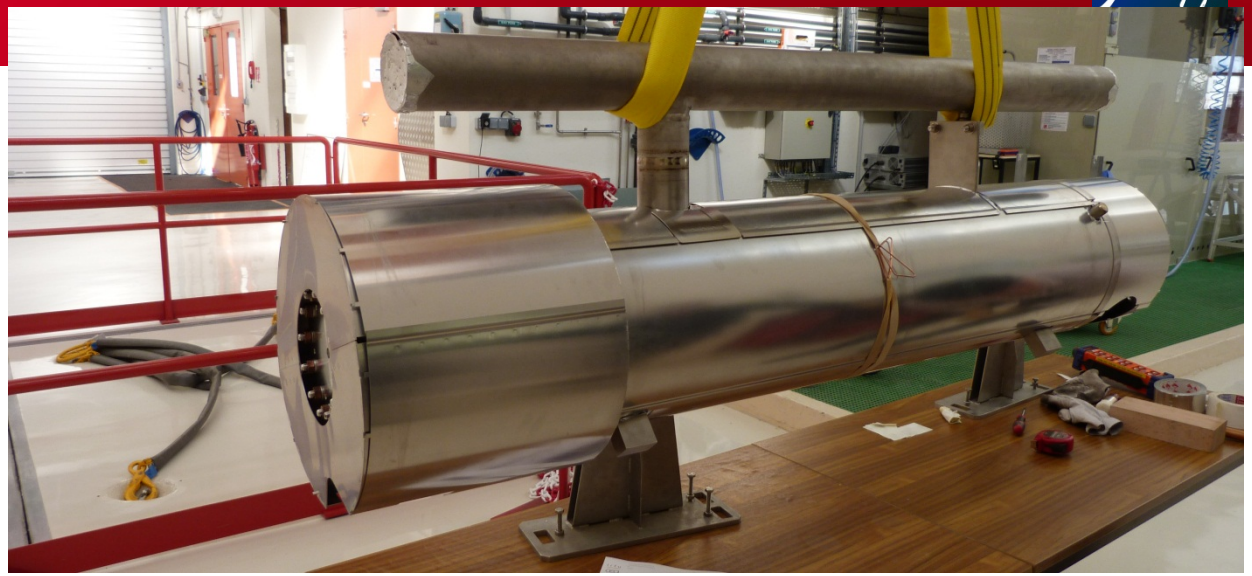


Tuning system assembly on cavity n
n=[2;8]

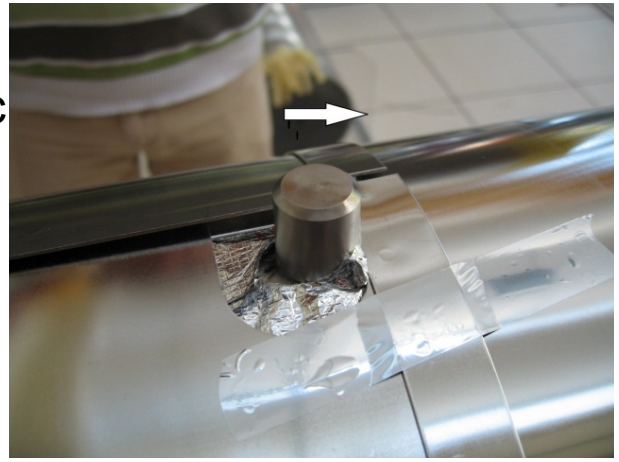
Written by		Checked by		Approved by	
Name	Yanick SALICE	Name	Jean-Pierre CHARRIER	Name	Catherine
Function	Technician	Function	Assembly hall manager	Function	System
Date		Date		Date	
Signature		Signature		Signature	

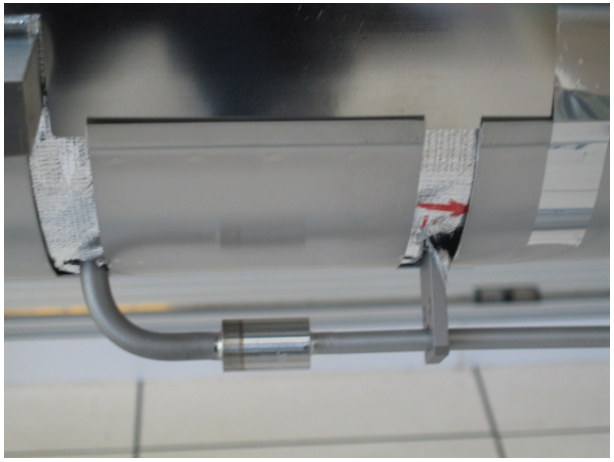
Magnetic Shieldings: PXFELs & XM-3

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



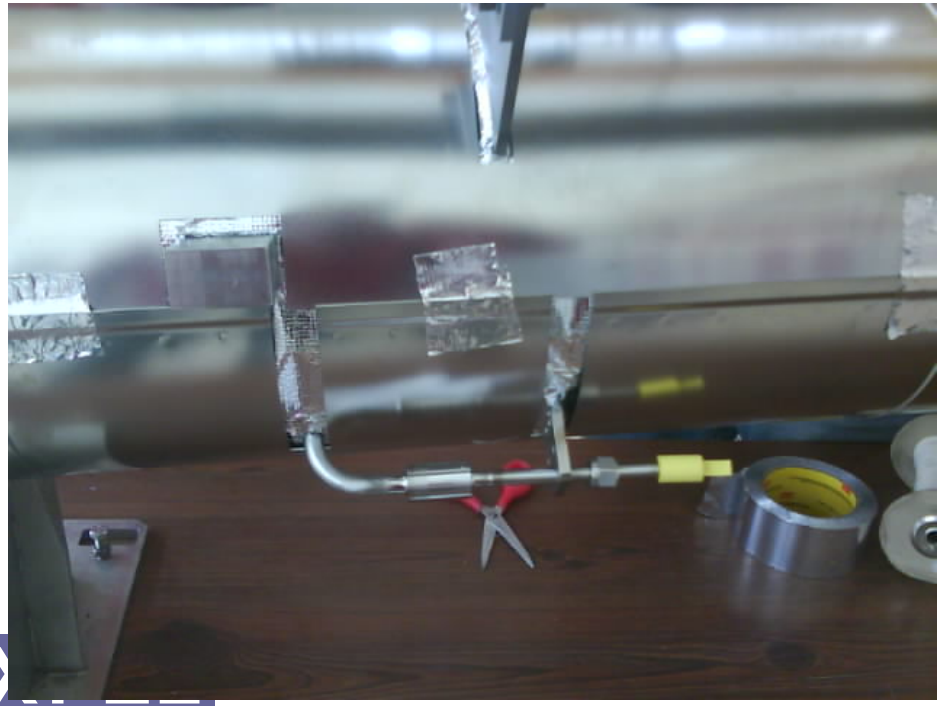
Pre-series by MecaMagnetic for XFEL configuration (warm-up tube with Ti/SS transition): benchmarking XM-3 cavities !



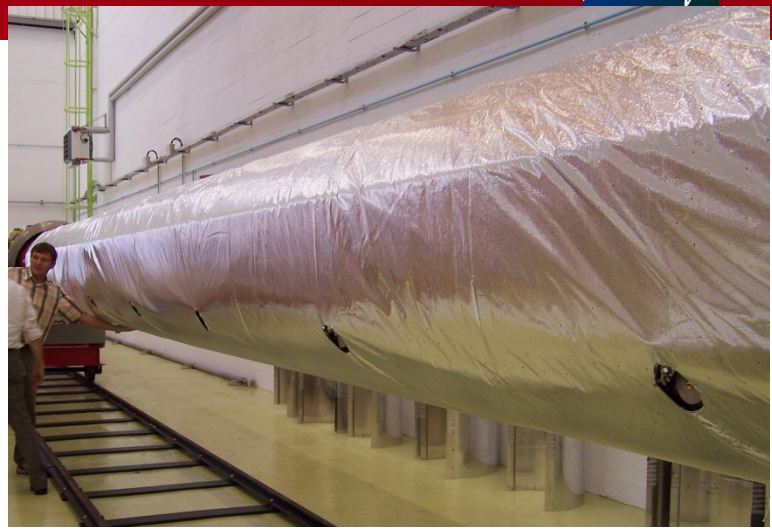


Magnetic Shieldings: XM-2

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).

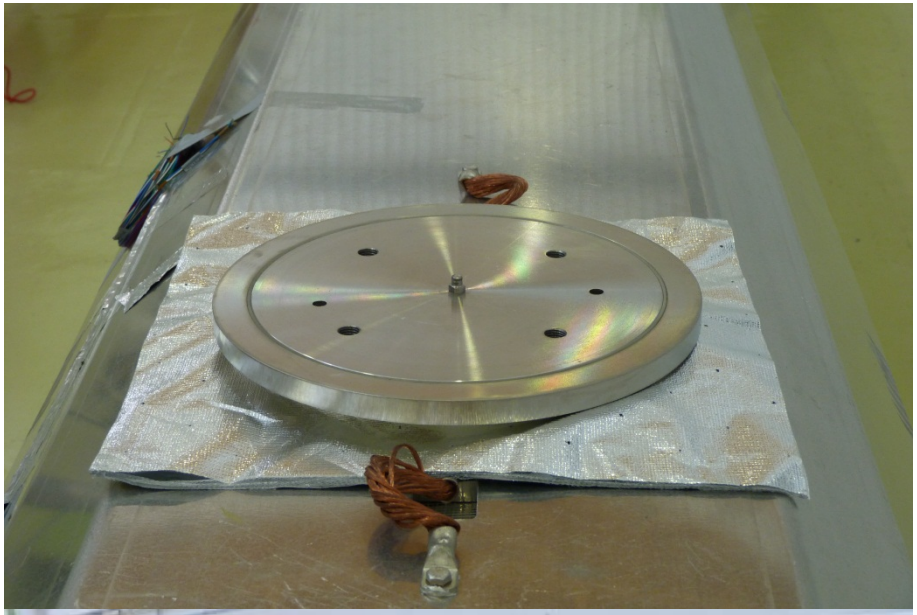
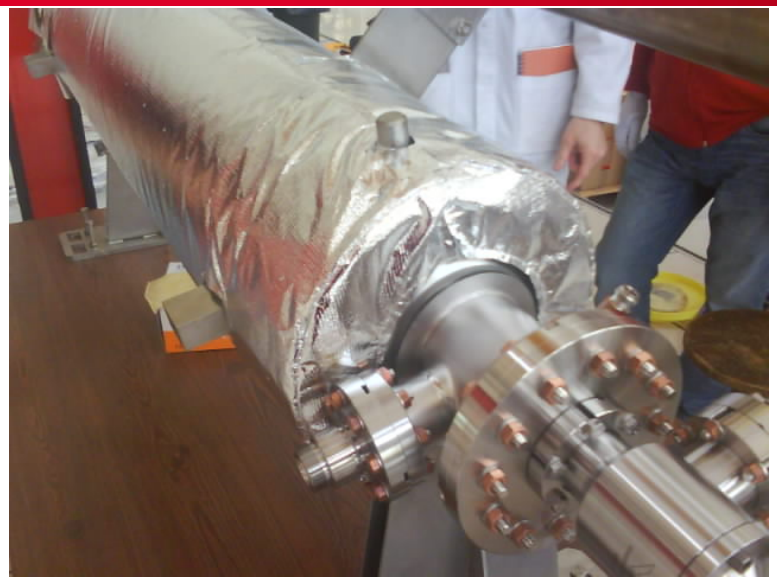
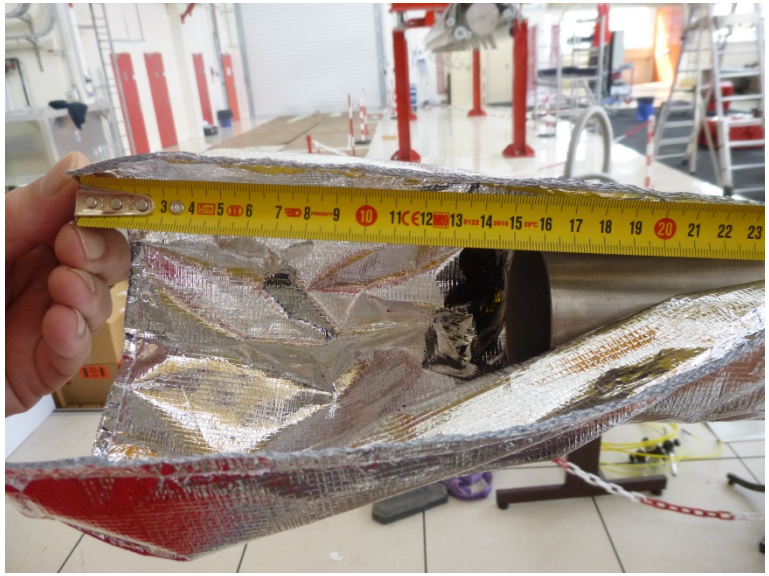
Cryo loss at	PXFEL 3	PXFEL 3_1 cooldown Dec 2011	PXFEL 3_1 cooldown Feb 2012	PXFEL 2_3 cooldown March 2013
40 / 80 K	134 W	96 W	97-102 W	95 W

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