



O. Napoly, CEA-Saclay, Irfu/SACM

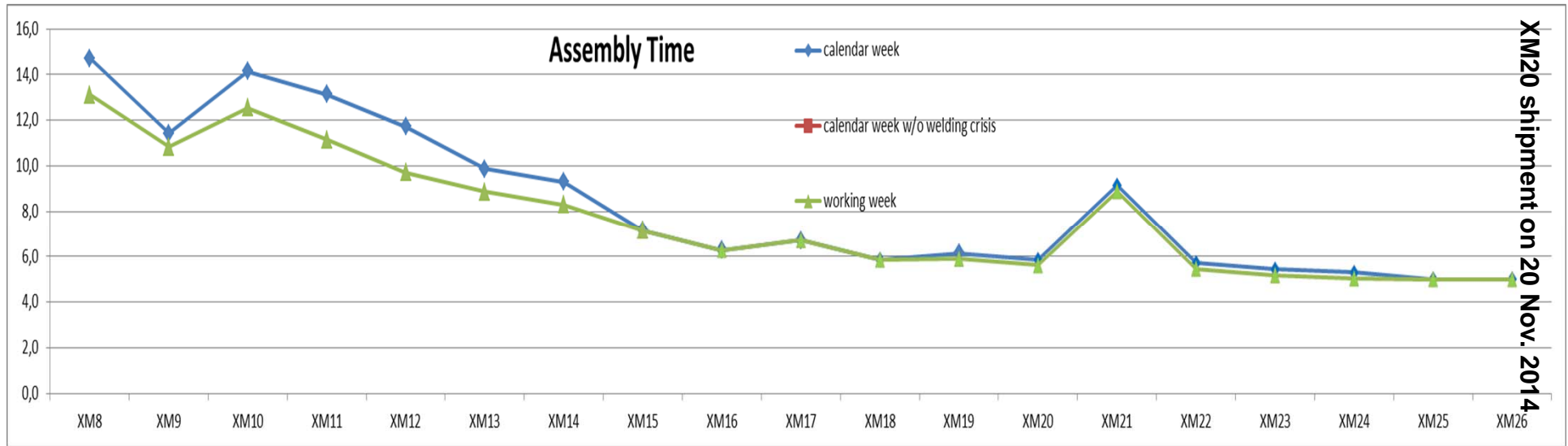
- Status of Assembly
 - Assembly schedule
 - RF tests
- Acceleration of production
- Conclusions

**CEA contributes to the
XFEL Cold Linac construction
through
String Assembly in Clean Room (WP9)
and Module Assembly (WP3)**



**Accelerator Module Assembly
assembly of 103 accelerator modules
with 1 per week throughput !
operated by an industrial contractor
on the **Saclay** site.**

Status of Assembly: 20 cryomodules delivered to DESY

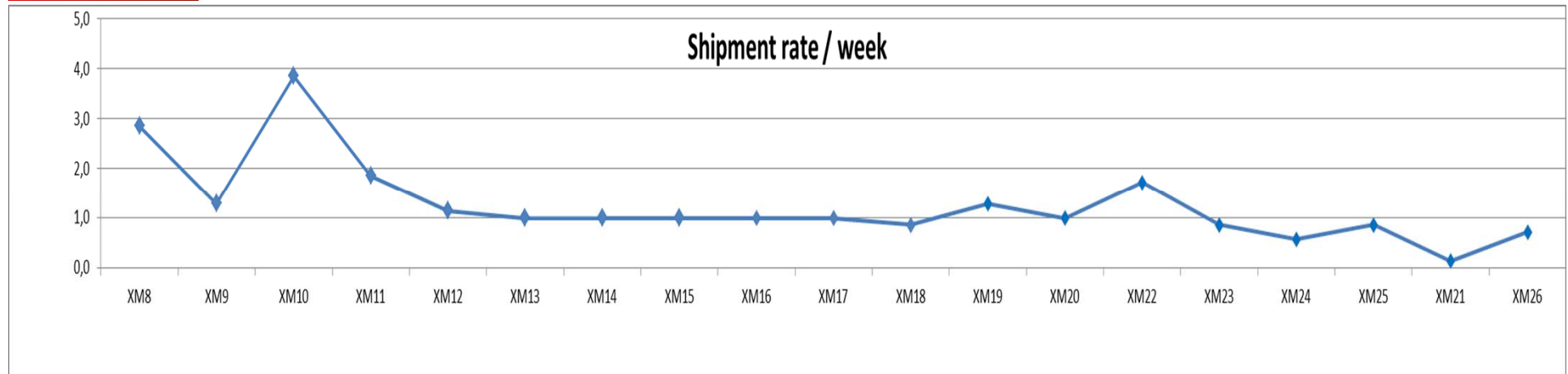


The nominal assembly time of 7 weeks has been reached with XM15.

With 7 workstations in parallel, this means that all **organisation / reception / assembly / test / transfer / documentation** work for one cryomodule is concentrated in **40 hours** (1 week), actually ~1800 man.hour labor
 about 33 FTE from Alsyom-SEIV
 about 10 FTE from CEA

Versatility is needed (no 'groups' like RF, Cryos, Vacuum for 30-33 FTE) but Specialization is also required for efficiency

Status of Assembly: 20 cryomodules delivered to DESY



The nominal throughput of 1 module per week has been reached since XM12 (24/09/2104).

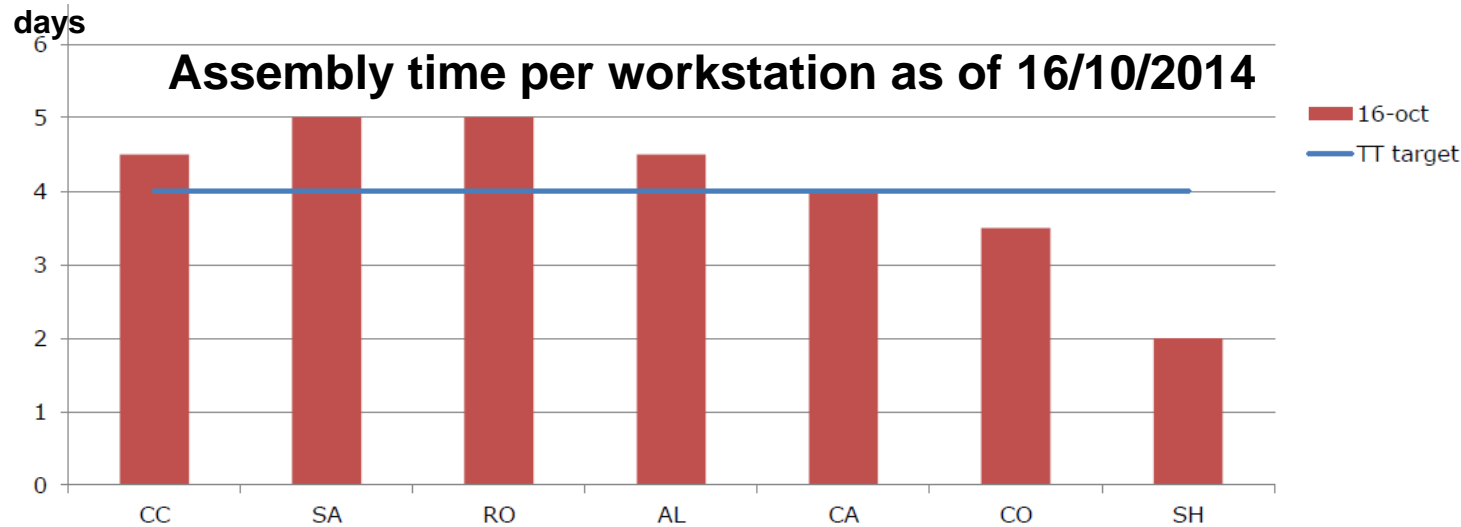
Assuming 1 CM/week from then on:

- XM24 shipped end of 2014
- XM71 shipped end of 2015
- XM82 shipped end of March 2016
- XM100 shipped 2nd August 2016 (w30)

Input:

- 8 days off at Xmas 2014 and 2015
- 2 weeks Clean Room maintenance in 2015
- 1 week Clean Room maintenance in 2016

Status of Assembly: 4-day throughput in sight



Assuming 1.25 CM/week from end of November 2014 (throughput of 1 Module / 4 days):

- XM25 shipped end of 2014
- XM83 shipped end of 2015
- XM98 shipped end of March 2016
- XM100 shipped 12 April 2016

Input:

- *8 days off at Xmas 2014 and 2015*
- *2 weeks Clean Room maintenance in 2015*
- *1 week Clean Room maintenance in 2016.*

CEA is concerned not only by the rate of production, but also by the quality of the production:

Warm coupler overheating crisis revealed

- lack of QC on WIC after RF conditioning
- weak specifications on central screw
- assembly errors on central screw and push-rod screws

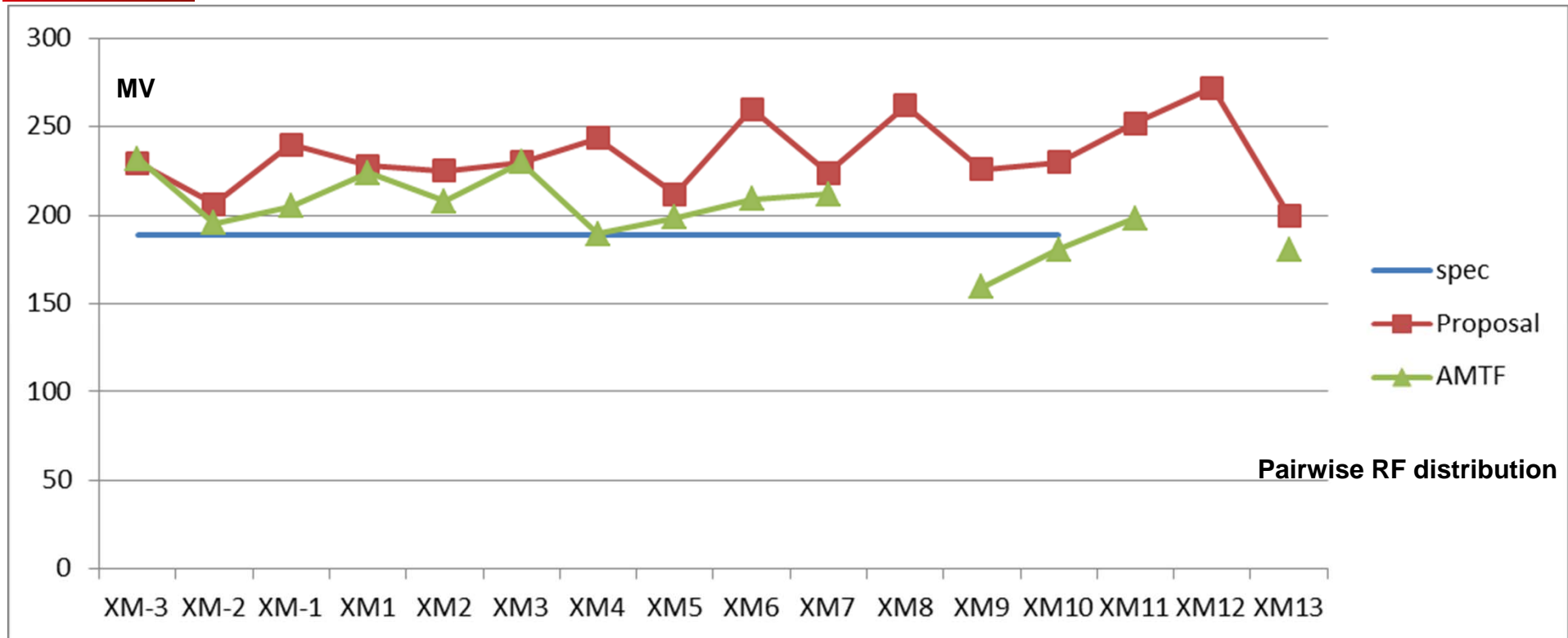
Corrective actions should be effective.

Gradient crisis is under investigation.

Other milder mis-fabrications were discovered on tuners, alignment devices, supports, etc...

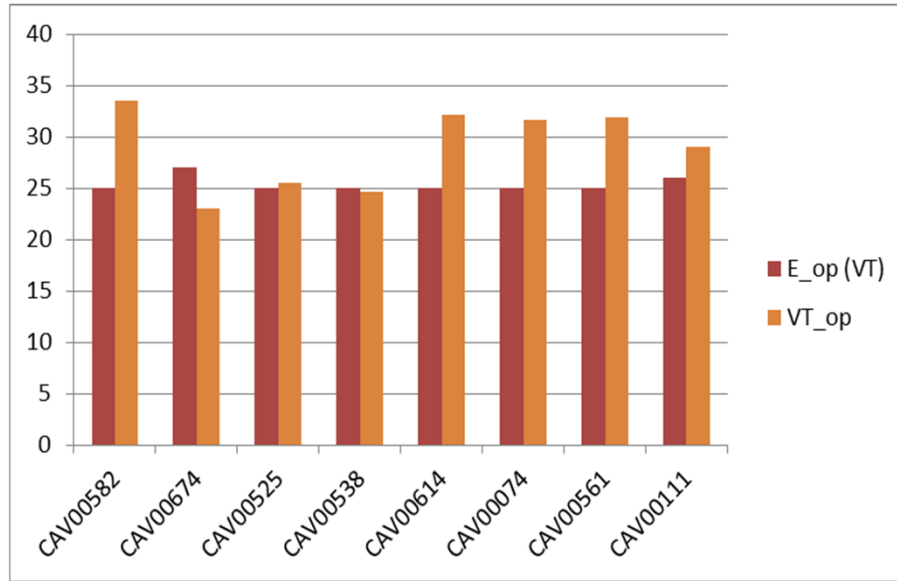
All modules (except XM-3 and XM-2) needed significant repair work before or after the AMTF RF tests.

Status of Assembly: 14 cryomodules tested at AMTF

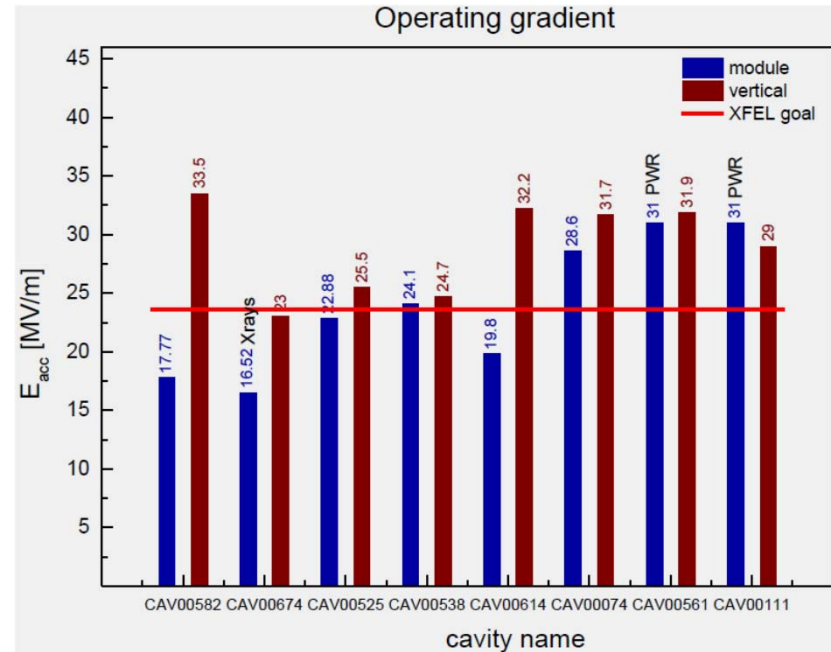


- Integrated over 14 modules: +7% above specs, -14% below VT 'reference' gradient
- Four modules lost about 50-60 MV: XM4, XM6, XM9, XM10 and XM11: main cause is early quench, but also large field emission.
- XM8 is parked after a leak detected on the 2K LHe circuit. Investigations will follow.

XM13 RF Test Results at AMTF



XM13 cavity selection communicated to CEA with 'E_op' gradients on **May 15, 2014**

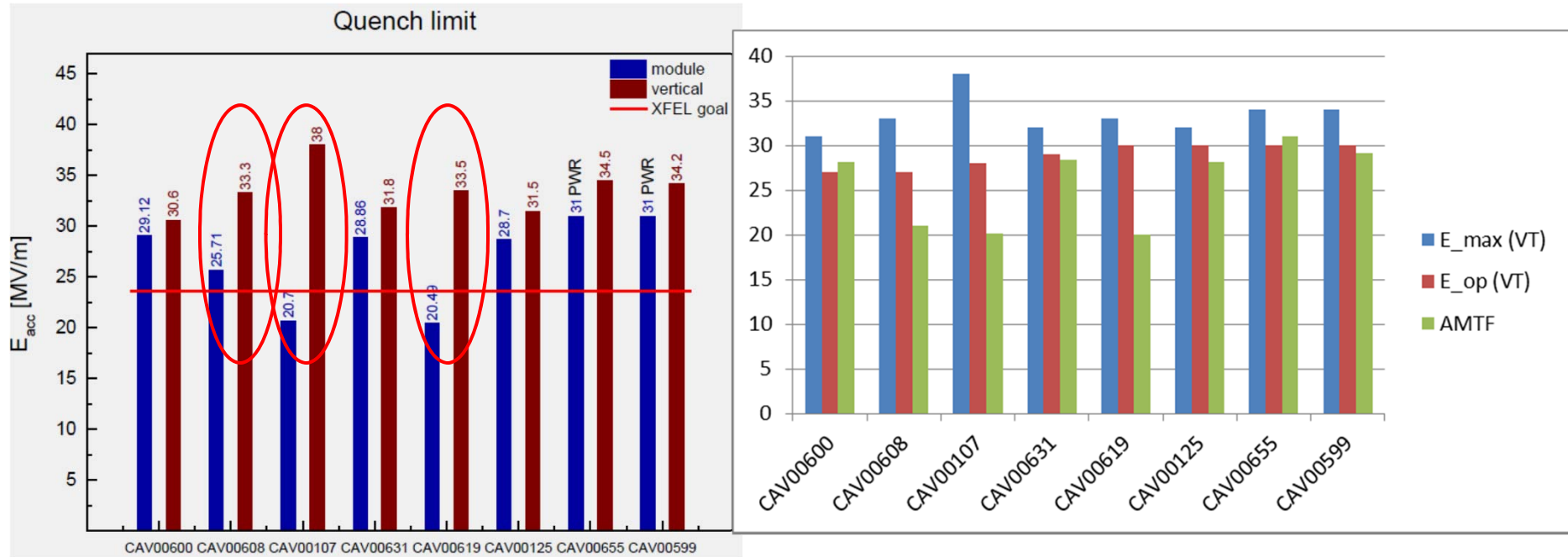


XM13 RF results at AMTF, with 'VT_op', communicated to CEA on **Nov 12, 2014**

There is indeed a degradation of cavity gradient, and many times, of the quench limits.

But CEA is concerned with the sudden change of **operating gradient 'reference'** without any upstream information.

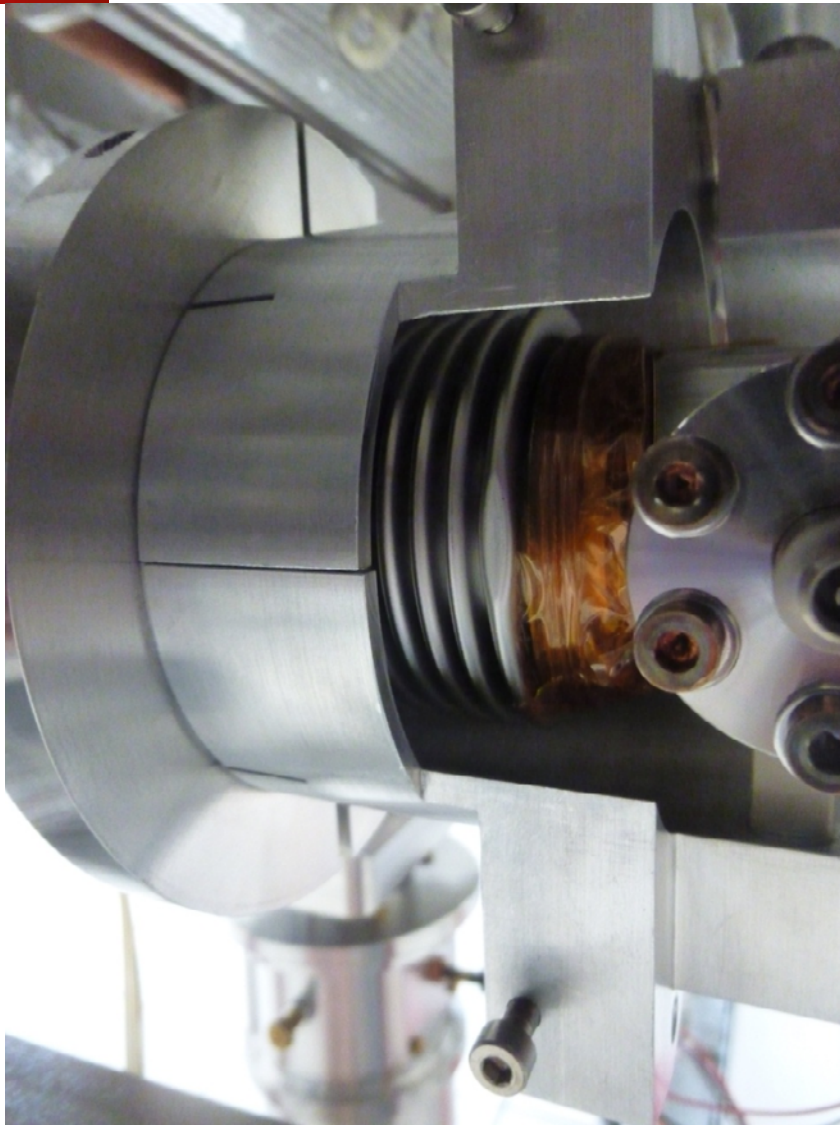
XM10 RF Test Results at AMTF



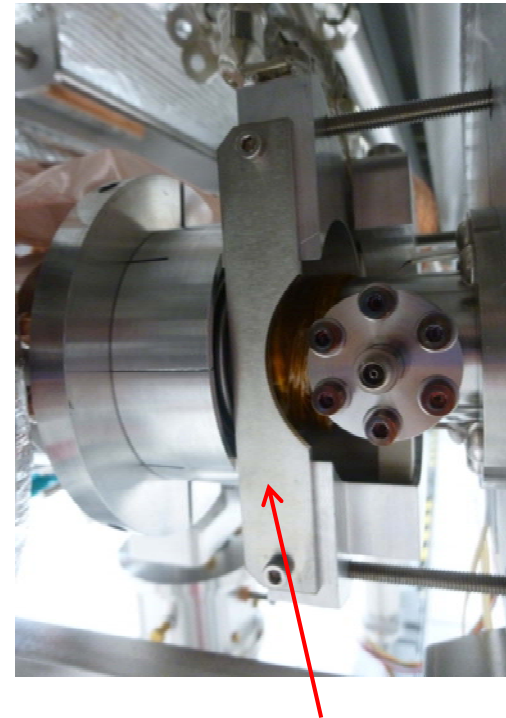
Cavities 2, 3 and 5 have very early quenches

- Vert. test average: 28,8 MV/m
- **Module test average: 22,6 MV/m by pairs**
- Module test average: 25,8 MV/m by single cavity power distribution
- XFEL specification: 23,6 MV/m

XM10 Incidents at Roll-out Assembly



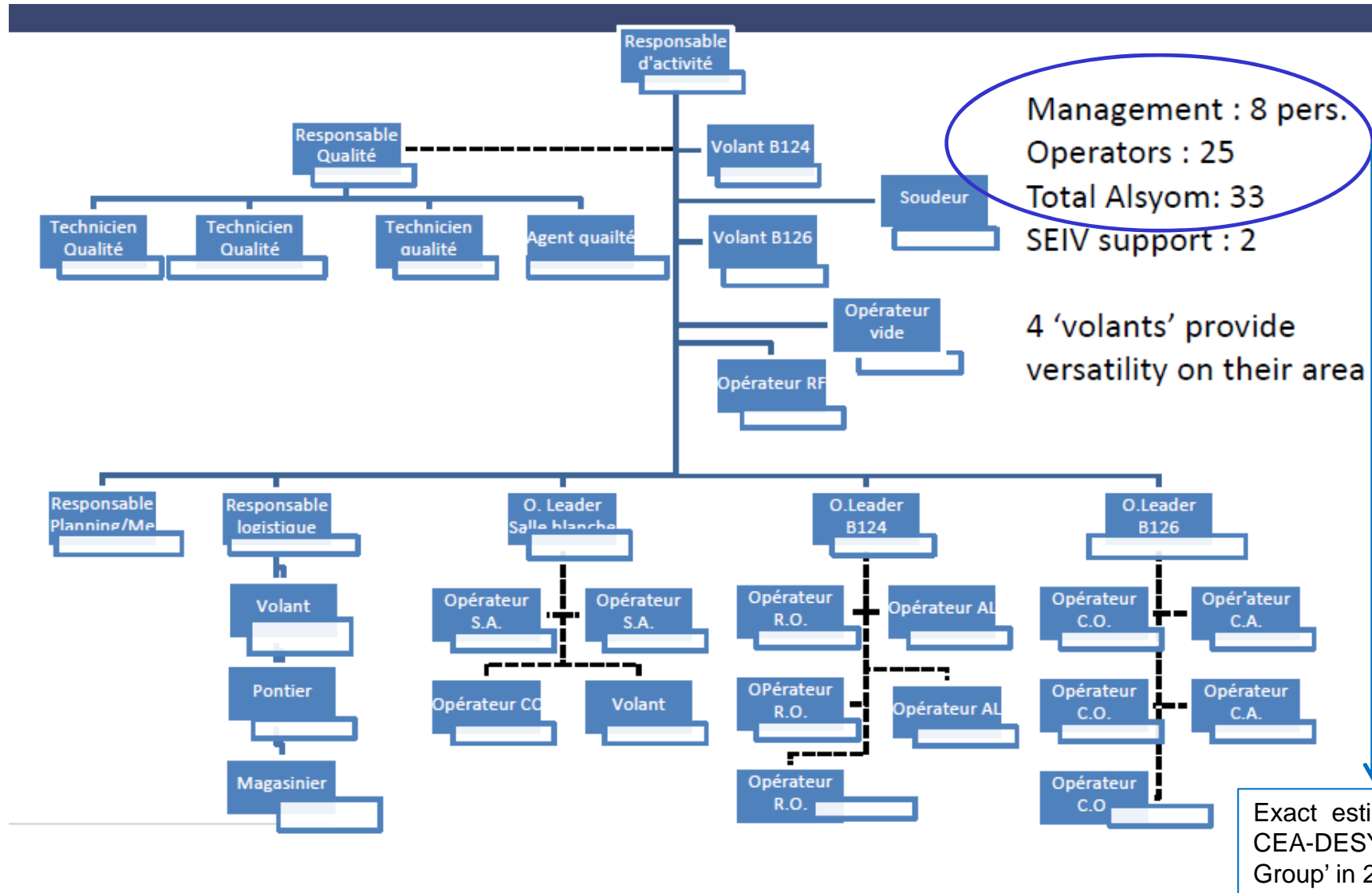
Cavity n°2 : dent on the coupleur bellow



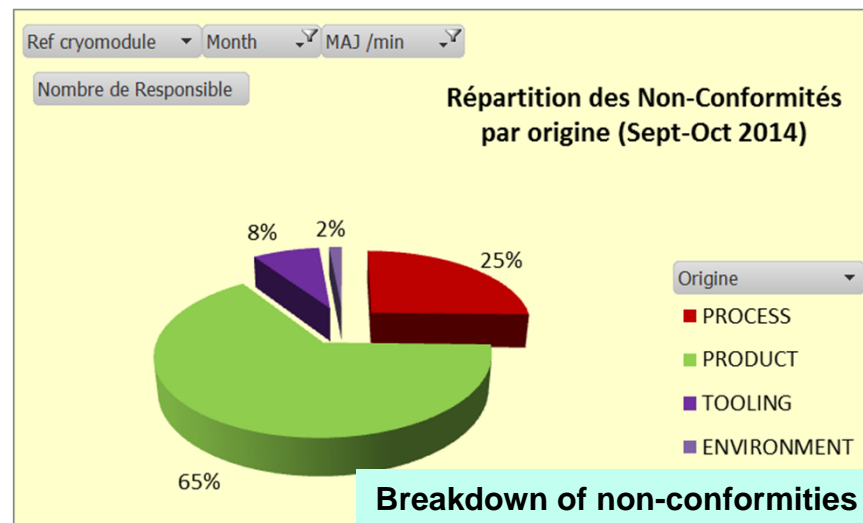
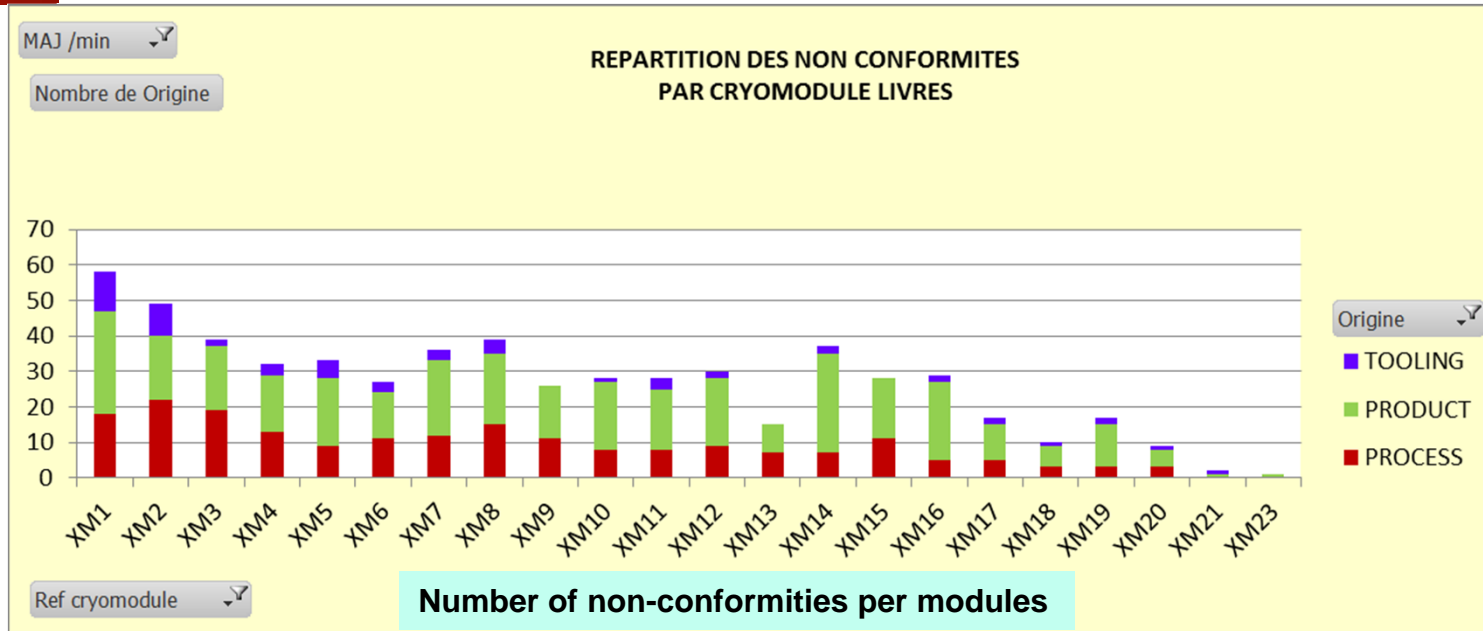
The dent might have been caused by the assembly of the part linking the two half 4K-interfaces.

Progress: Alsyom Organisation

Alsyom had modified its internal management organisation and staffing:



Progress: Non-Conformities



Leaks on LHe Circuit on XM19



Leak on the 2K service tube of XM19 cryogenic distribution system



This leak introduced a delay of 3 days for the repair and the inspection by DESY and TUV.

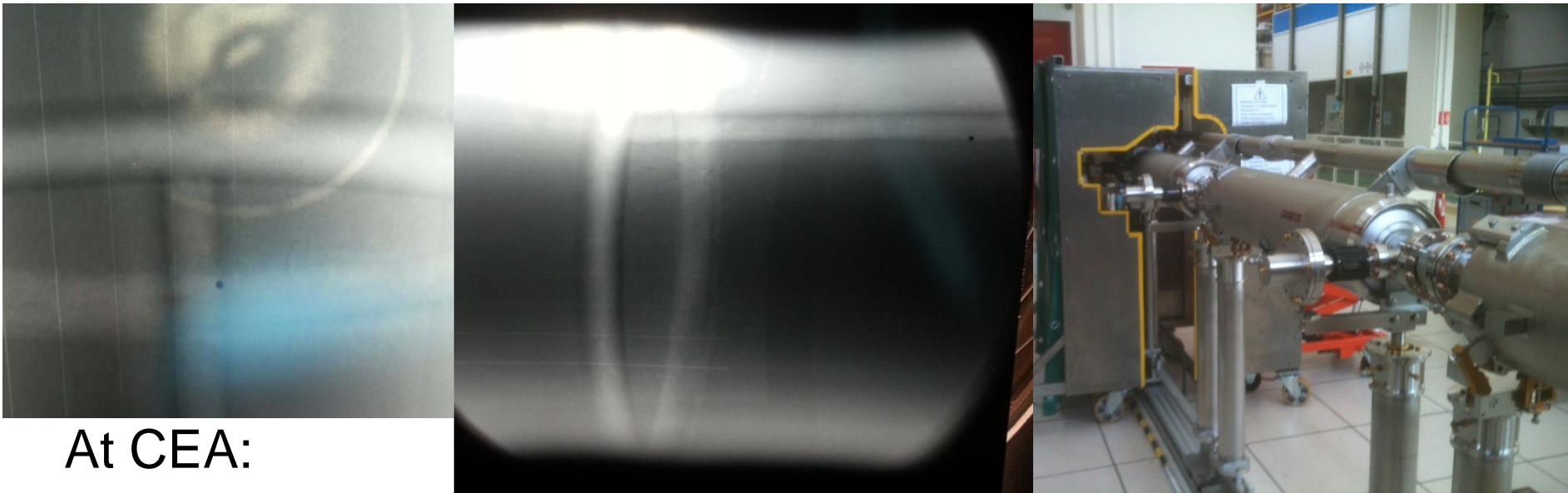
Still XM19 will be shipped on week 46, with one day of delay w.r.t. the original plan.

Note that week 46 includes only 3 working days but this will be compensated.

Porosity problem remained from the longitudinal weld (16/76) of the 'cavity1 extension pipe' to cavity 1 upstream pipe.

Orbital welds 16/76 of XM14 and XM15

Lead cabin



At CEA:

- X-Ray radiography contract with SGS from XM15, including X-Ray of repairs within 24h, accepted by SGS.
- Lead protections in place allow for stand-alone radio campaigns since XM14

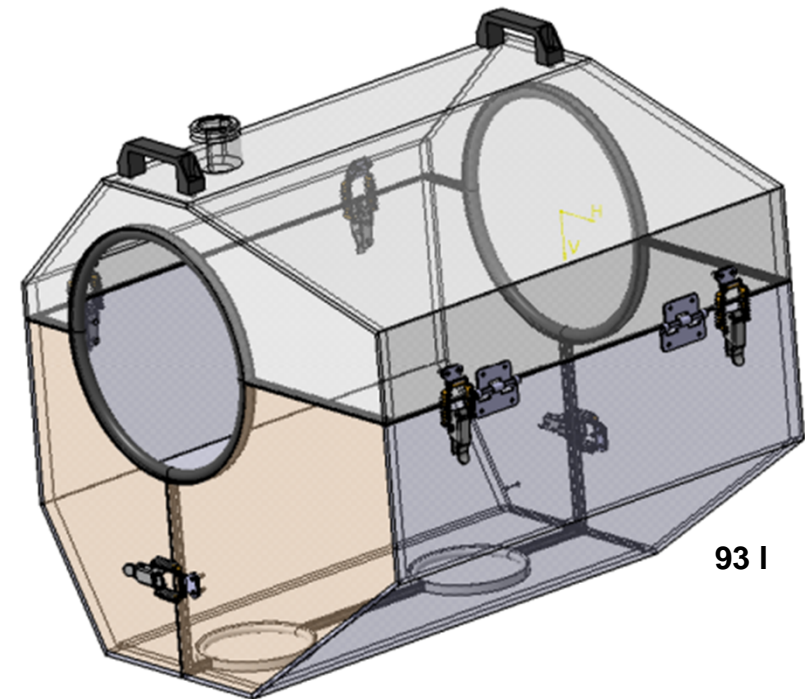
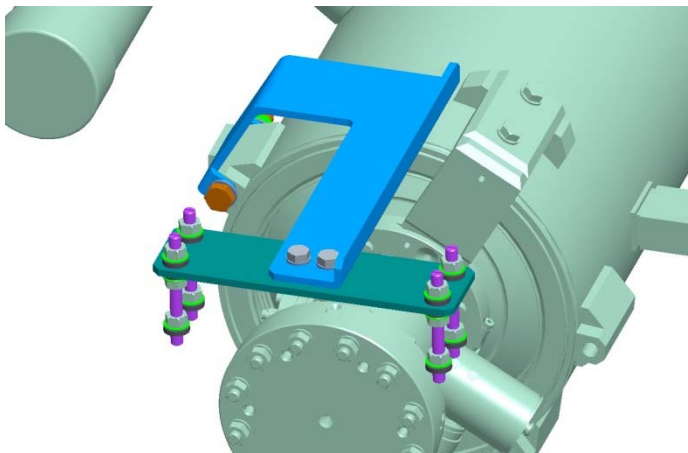
Are we entering the 'pacific ocean' of routine operation, after Cape Horn ?

Acceleration of Production

- The nominal production rate has been established.
- 25% higher throughput is feasible but not yet solid.
- **Acceleration of production is aiming at consolidation of 4 day-throughput**
- Many fabrication problems have been detected at AMTF, including large cavity RF degradations, coupler and tuner bad assemblies. Corrective actions and investigations are underway.

Actions on short term:

- 1) Pre-fabricated et reusable devices for the leak-check of
 - the cavity string connections → delivery of one prototype on 19/09/2014, needed adjustment, 4 units under fabrication
 - the cold coupler pairs in the clean
- 2) Realization of gate valve support for its assembly on cold-coupler WS:
Design and fabrication taken over by Alsyom, used for XM22.



Inter-cavity connection leak-check box, including cold coupler connection

Actions on the short term:

- Reinforce the quality control team to detect non-conformities, if possible ahead of assembly, and to document them
- With INFN, fix the low reliability of the tuner electric control bench and commission a second bench to avoid its transfer across the XFEL Village.

Actions on the medium term:

- Test and implement a solution for faster cavity string connections by anticipating individual cavity venting on the coupler assembly workstation
- Commission the second workstation for warm coupler assembly

Proposals for the short term:

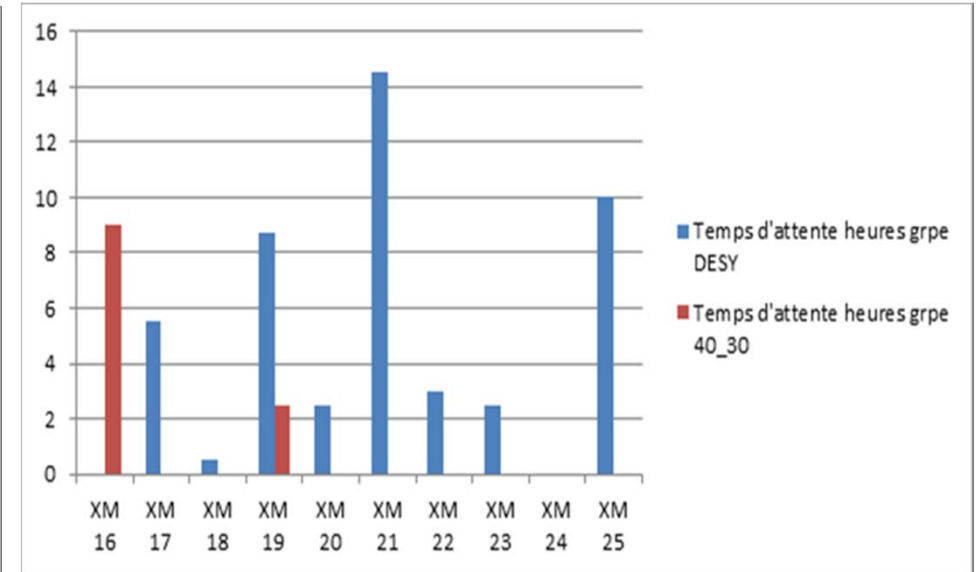
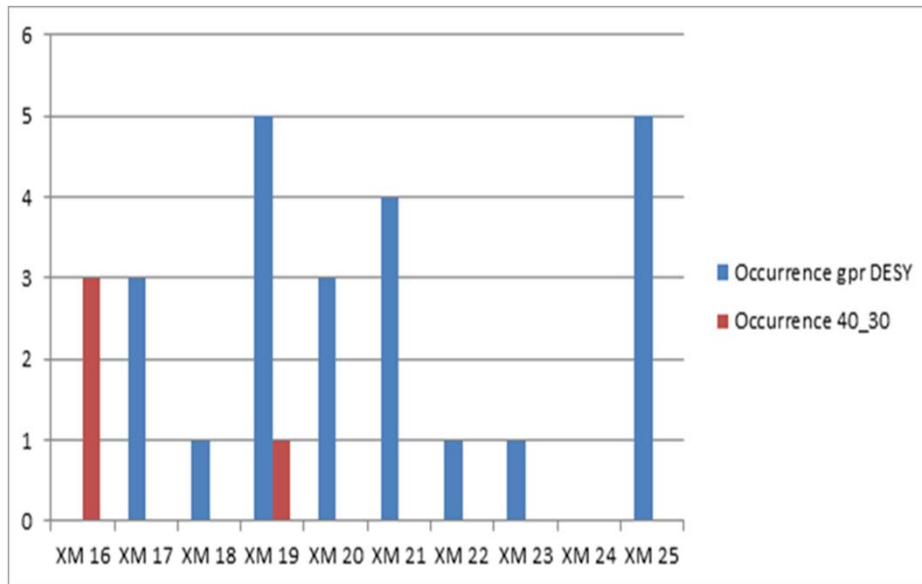
- Cutting coupler holes in the 4K blankets is not an industrial solution, especially when the blanket hangs from the wrong side.



→ Go for pre-cut blankets

Proposals for the medium term:

- Higher reliability of vacuum systems is required



On average: 2.7 interruptions of RGA communication per modules, 4.7 hours assembly time lost per module

- Increased productivity with 4 functionalities PUMP, VENT, FLUSH, RGA

Proposals for the medium term:

- Welding Titanium bellows with pure Argon, instead of He-Ar, would save
 - Allow for very fast and efficient global leak test of the 16 individual Titanium welds
 - the long and uncertain time needed to pump and N₂ purge of the LHe tank before the Helium leak test by external accumulation for the final leak test.
- Exemption to perform leak test with 2×10^{-8} mbar.l/s Helium background leak of 1×10^{-8} mbar.l/s requested to DESY for XM23 and XM24.

The nominal production rate 1 CM/week is reached.

The next fight is cryomodule **performance**, avoiding repair work.

Alsytom is currently working on a plan for acceleration of production with the goal to **consolidate the 4-day throughput organisation**:

- Final plan presented on 4 November to CEA
- CEA is currently analyzing this plan and its consequences on cost and manpower at CEA
- The DESY, E-XFEL GmbH and E-XFEL council were communicated with this acceleration plan.



Back Up Slides: XFEL Village Infrastructure

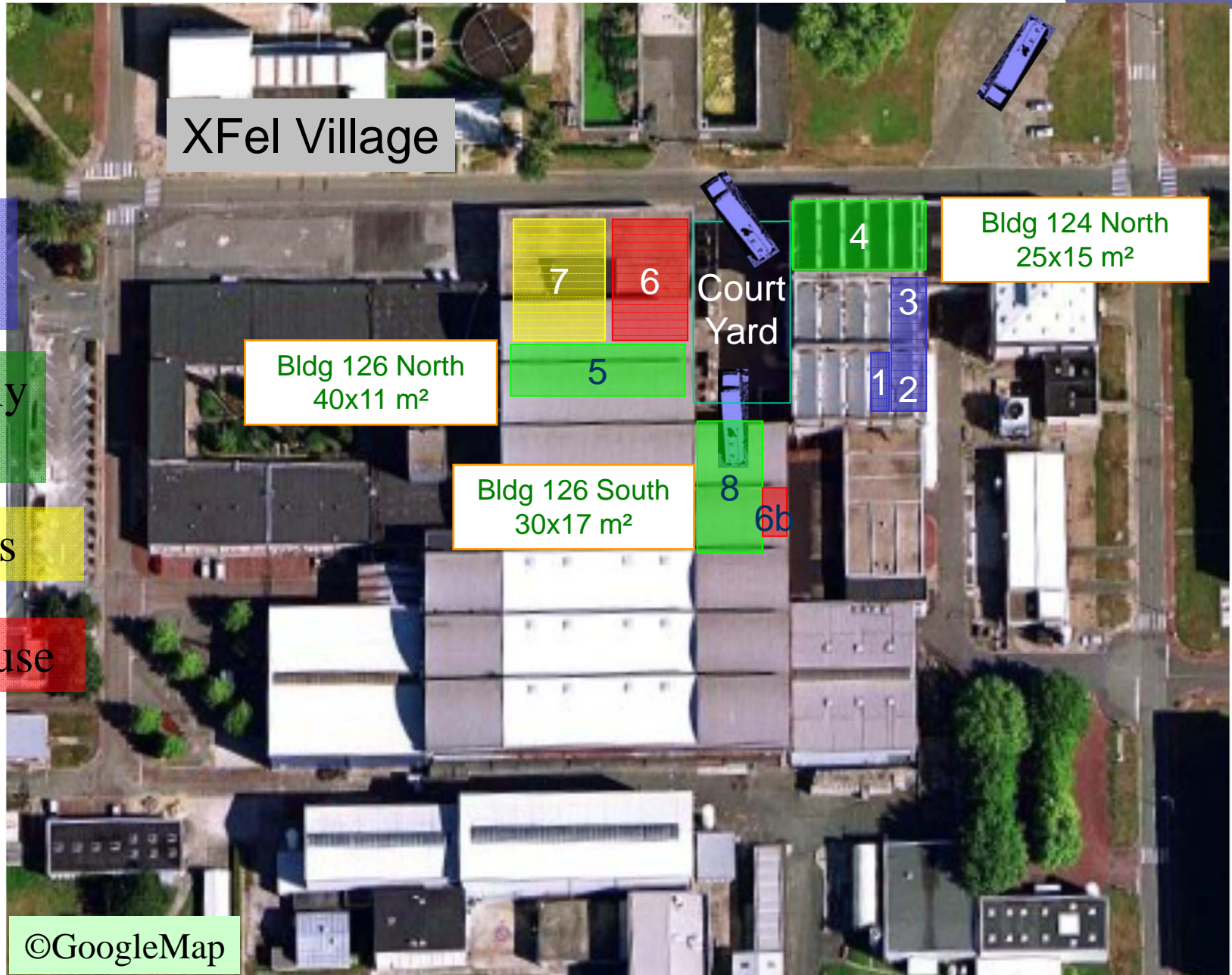
Overview of the Assembly Buildings

Clean rooms

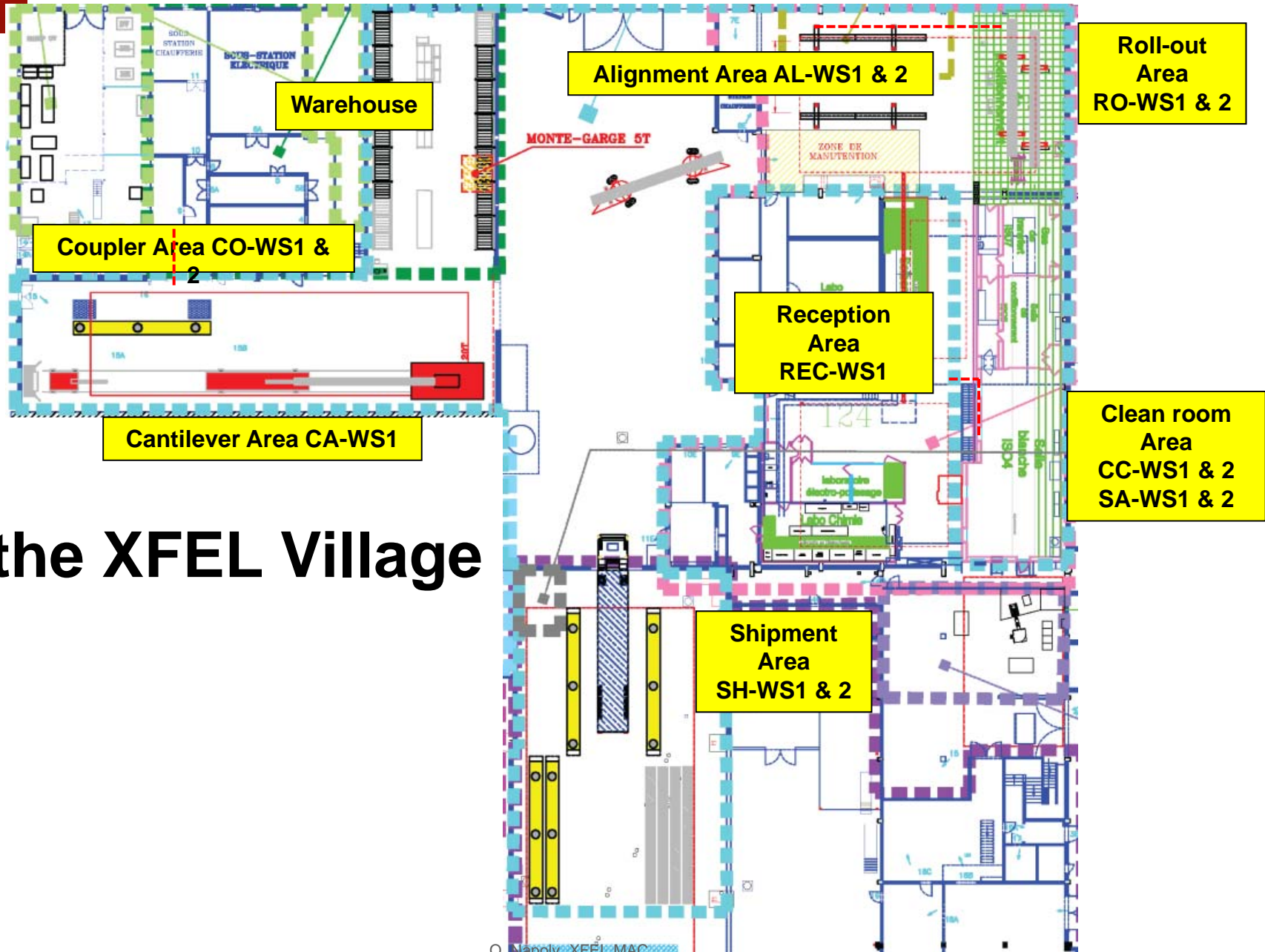
Assembly halls

Offices

Warehouse



Assembly Hall : Workstations



the XFEL Village

1. **Clean Room Cold Coupler Area** (IS04-CC-WS1)
 - Cold coupler assembly (x8)
 - Leak check of cavity-coupler connection (+RGA)
2. **Clean Room String Assembly Area** (ISO4-SA-WS1, ISO4-SA-WS2)
 - String connections (1 gate valve + 8 cavities + 1 Qpole unit)
 - Leak check of string and N₂ venting (+RGA)
3. **Roll-out Area** (RO-WS1, RO-WS2)
 - HOM adjustment, magnetic shielding, T-sensors (x6)
 - Tuner assembly (x8), coupler 4K and 80 K shields
 - 2 Ph-tube welding, NCT (LT, PT, RT)
 - Cold-mass/string connection
4. **Alignment Area** (AL-WS1, AL-WS2)
 - Cavity and quadrupole fine alignment (~100 µm)
 - Welding of 8 mm LHe filling line (x9)
 - Tuner and piezo electric tests
5. **Cantilever Area** (CA-WS1)
 - Welding of 4K and 70 K shields, 4K and 79 K super insulation
 - Cable routing and insulation, Quad current lead
 - Insertion into vacuum vessel and cold mass alignment
6. **Coupler Area** (CO-WS1, CO-WS2)
 - Warm couplers + coupler pumping line + leak checks (8 connections + coupler vacuum)
 - Cabling of flanges A (x8) and flange D
 - Quadrupole current lead connections and welding
 - Final leak check of cavity vacuum + final pumping
7. **Shipment Area** (SH-WS1, SH-WS2)
 - Control operations (RF frequency)
 - End-caps closing, N₂-insulation
 - CEA-Alsyom “acceptance test”
 - Loading

Progress Report



XM4 (String assembly) on 14/02/2014

Progress Report



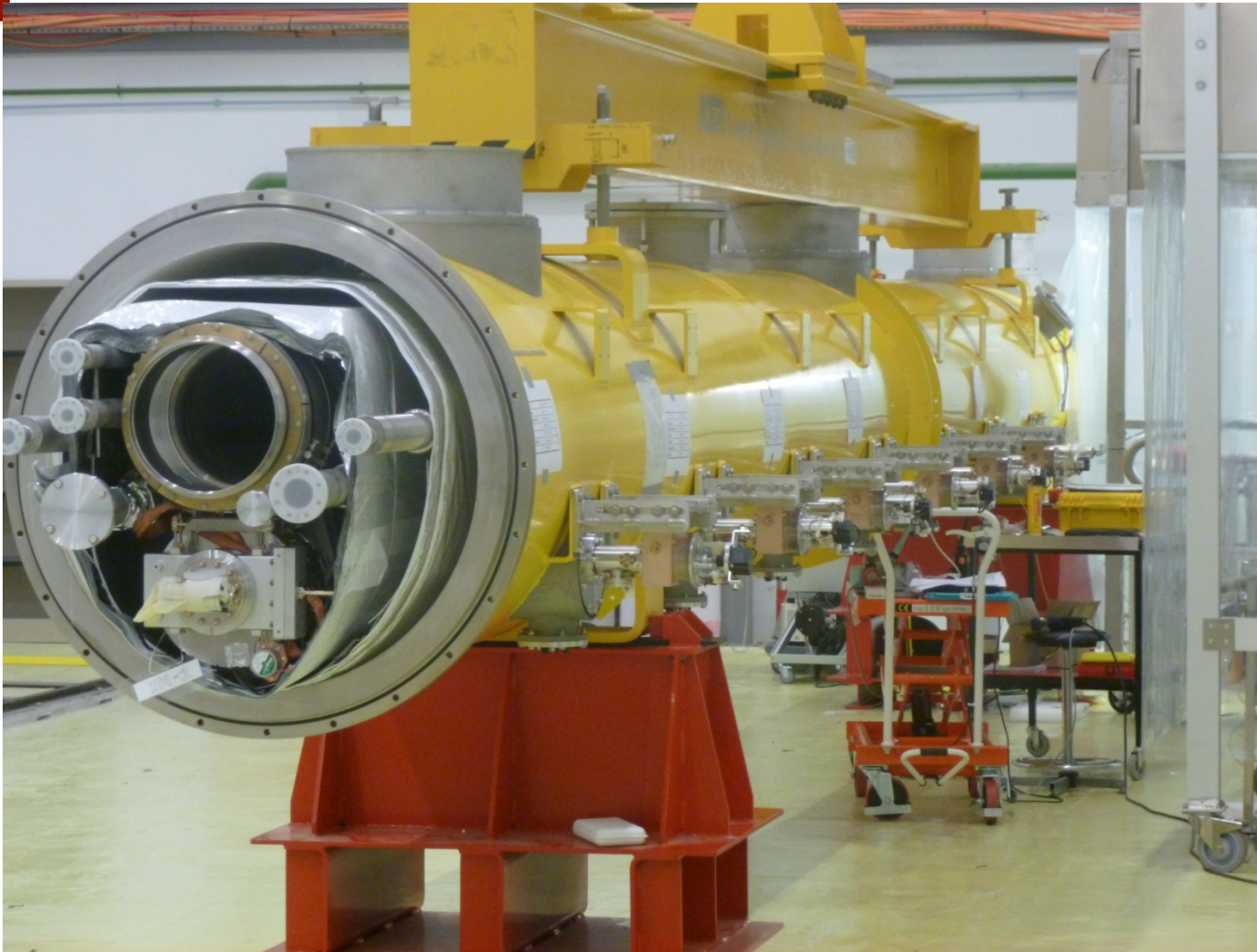
XM2 (Alignment) and XM3 (Roll-out) on 14/02/2014

Progress Report



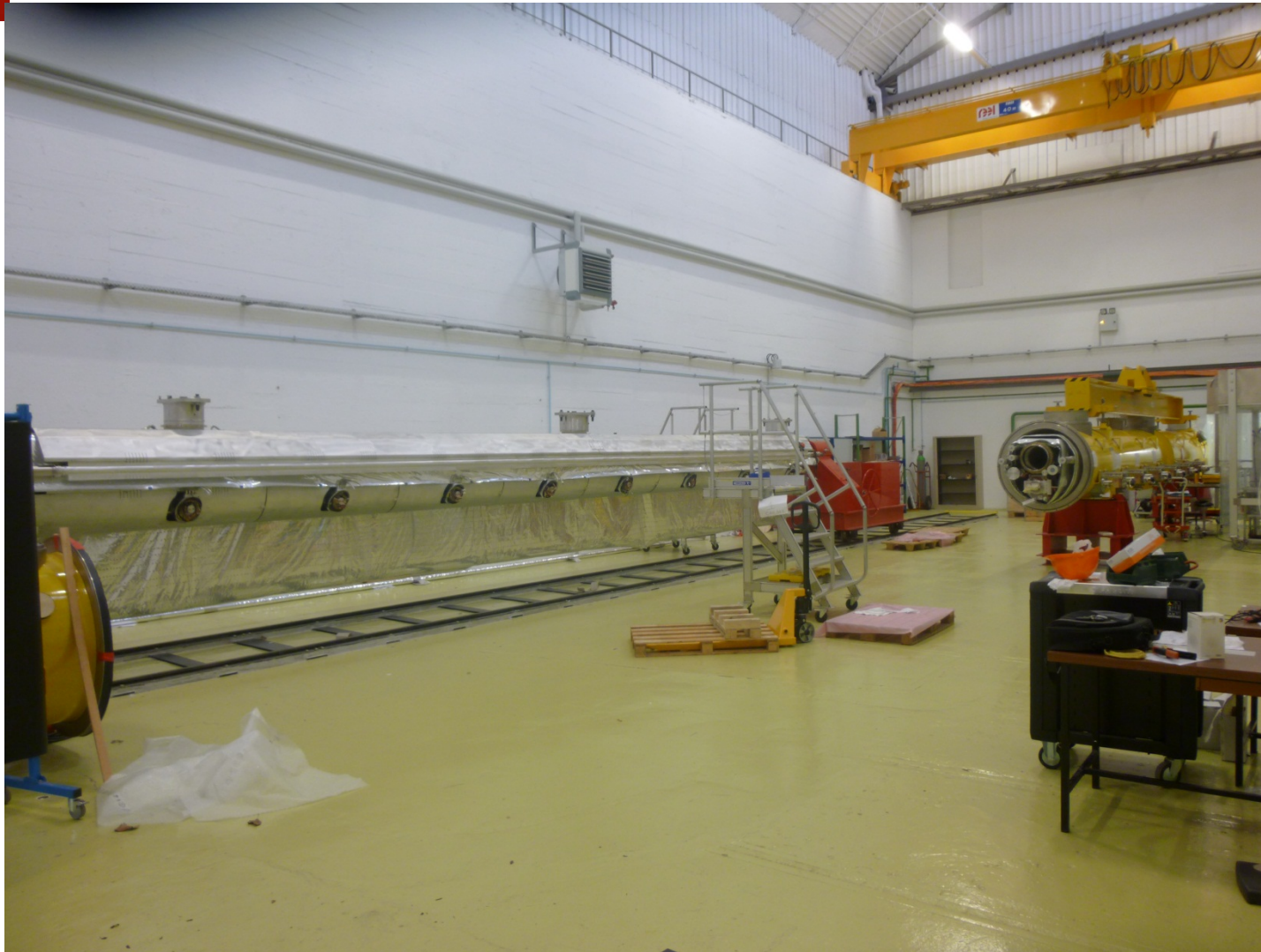
XM1 (Cantilever) on 14/02/2014

Progress Report



XM-1 (Warm couplers) on 14/02/2014

Progress Report



XM1 (Cantilever) and XM-1 (Warm couplers) on 14/02/2014

Progress Report

