STATUS OF E-XFEL STRING AND CRYOMODULE ASSEMBLY AT CEA-SACLAY

C. Madec, CEA-Saclay, IRFU/SACM
CEA contributes to the E-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.
Project Timeline

Our effort develops over the 3 phases:

Phase 1: 2008-mid 2010
- Preparation of Infrastructure and Tooling

Phase 2: August 2010 → August* 2012
- Pre-industrial studies subcontracted
- Training and Commissioning at Saclay with XFEL Prototype Modules (PXFEL2 and PXFEL3)
  → leading to Restricted Call for Tender for Assembly Contract, July 2011

Phase 3: July 2012 → Q1-2015
- XFEL module assembly by industry operator
Outline

• XFEL Village at Saclay
• Integration of cryomodule prototypes PXFEL2, PXFEL3
• Definition and Schedule of industrial integration of XFEL cryomodules
XFEL Village at Saclay
Assembly Hall : Workstations

the XFEL Village

Warehouse

Coupler Area CO-WS1 & 2

Cantilever Area CA-WS1

Alignment Area AL-WS1 & 2

Reception Area REC-WS1

Roll-out Area RO-WS1 & 2

Clean room Area CO-WS1 & 2 SA-WS1 & 2

Shipments Area SH-WS1 & 2
Phase 2: Training and XFEL Village Commissioning with Prototype Modules (PXFEL 2, PXFEL3)
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 on August 24\textsuperscript{th}, 2010
  – the module re-assembly of PXFEL2_1, tested at DESY
  – the string and module assembly of PXFEL3_1
    \textit{using DESY cavity posts and clean room tools}
  – the string assembly of PXFEL2_2 (Dec.2011 – August* 2012)
    \textit{using CEA cavity posts and clean room tools}
Assembly prototyping at Saclay

Cavity and Coupler Reception (ISO5-CR-WS1)

0.a Cavity and coupler reception
0.b Cavity and coupler washing
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...).
5. Cold Mass insertion (CA-WS1)
Assembly prototyping at Saclay

5. Coupler Warm Part assembly (CO-WS1&2)
   5.a coupler warm part assembly
   5.b coupler pumping line assembly
6. Final control and shipment (SH-WS1&2)
Lessons from Assembly Prototyping

PXFEL3_1 CMTB Test

PXFEL3_1
Cavities gradient limits

all cavities except C7 are limited by the breakdown

- PFEL goal
- HOMC1 not tuned
- high losses
Lessons from Assembly prototyping

• PXFEL3_1 : cavity 1 (FE) and cavity 8 (HL) do not reproduce their VT performances. The causes is not identified:
  – coupler contamination through common waveguide box ?
  – particulate contamination during string assembly ?
  – shocks during transport CEA-DESY: (4g on frame,1g on cryomodule) + (2g on frame ,2g on CM) events ?
  ⇒ Vibrations will be recorded during cold mass assembly and transfers on PXFEL2_2

• PXFEL3_1 : cavity 7 HOM2 badly tuned, lesson learned:
  ⇒ a successful RF measurement and HOM tuning campaign took place on PXFEL2_2 cavity string during Week 18, with the help of DESY and AMTF colleagues.
During the prototype phase, development of the quality assurance and quality control through the Acceptance Data Package (ADP) including:

- the certificate of conformity,
- the “as-built” configuration,
- the traveler,
- the test reports
- the non-conformities reports.

PXFEL2_2 ADP was built following our experience and needs, and it was delivered to DESY with the CM on Sept 4th, 2012 for approval.

The second CM acceptance stage will be based on the RF test at DESY.
Six NCR recorded for PXFEL2_2 string assembly

<table>
<thead>
<tr>
<th>NCR number</th>
<th>Model</th>
<th>Sub-assembly</th>
<th>Serial number</th>
<th>WS</th>
<th>MAI /min</th>
<th>Date</th>
<th>Object</th>
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<tr>
<td>CEA-XFEL-RNC-11-011</td>
<td>PXFEL 2_2</td>
<td>Cavity</td>
<td>AC 147</td>
<td>Reception</td>
<td></td>
<td>08/12/2011</td>
<td>Orientation of the angle valve + pin of the HOM2 connector + vacuum above 10^-5 mbar @ reception</td>
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<td>CEA-XFEL-RNC-12-012</td>
<td>PXFEL 2_2</td>
<td>Cavities</td>
<td>AC150 &amp; AC149</td>
<td>ISO 4 CC</td>
<td></td>
<td>10/02/2013</td>
<td>Water behind the flange of the elbow valve</td>
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<td>PXFEL 2_2</td>
<td>Coupler</td>
<td>AC3C2</td>
<td>ISO 4 CC</td>
<td></td>
<td>20/02/2013</td>
<td>Coupler antenna tilted</td>
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<tr>
<td>CEA-XFEL-RNC-12-014</td>
<td>PXFEL 2_2</td>
<td>Cavity</td>
<td>AC 150</td>
<td>ISO 4 CC</td>
<td></td>
<td>20/02/2013</td>
<td>Problem on cavity venting with UP34</td>
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<tr>
<td>CEA-XFEL-RNC-12-015</td>
<td>PXFEL 2_2</td>
<td>Couplers</td>
<td>CP3CS &amp; CP3CS</td>
<td>ISO 4 CC</td>
<td></td>
<td>22/02/2012</td>
<td>Remise à la PA rapide</td>
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<tr>
<td>CEA-XFEL-RNC-12-016</td>
<td>PXFEL 2_2</td>
<td>Coupler / cavity</td>
<td>CP3CS5 / Z 162</td>
<td>ISO 4 CC</td>
<td></td>
<td>22/02/2012</td>
<td>Outillage monté à Tvers / pour pouvoir démonter l'outillage nécessité d'ônérer le coupleur.</td>
</tr>
</tbody>
</table>

Example:

tilted coupler antenna

The coupler antenna is tilted in the horizontal plane, the coupler being in the support frame ready for connection to the cavity. The bellow holders were in position and tighten.

Reference documents:

The tilt of antenna axis was estimated at the half of the slot flange (for the leak test) i.e. 2.5 mm at the top of the antenna the tilt was about approximately 4 mm (cf. drawing page 4).

CORRECTIVE ACTIONS (equipment concerned by NCR/CR):

On Friday 17th, we dismounted the coupler AC3C2 from the cavity Z141 and checked the antenna (pictures page 2, during disassembly). The coupler is now mounted back on a TWG.
Assembly Industrialization
Assembly Industrialization

Contract for 103 CM integration awarded to ALSYOM in July 2012.

- The first phase (until Dec 2012), consists of:
  - the observation by ALSYOM of the assembly by CEA of the first pre-series cryomodule (XM-3)
  - the deployment of their industrial method based on the outputs of the prototyping
  - the set-up of the storage area,
  - the ERP (entreprise resource planning) parameterization

- The second phase:
  - training of the company team attended by the CEA team on the assembly of the second and third pre-series modules XM-2 and XM-1.

- The third phase: From XM1 on,
  - ALSYOM in charge of the series module assembly.
  - six months ramp-up period to reach the production rate of 1 CM per week.
CONCLUSIONS

The CM factory is ready to start the assembly of the XM-3 pre-series XFEL cryomodule on September 17th, 2012.