Cryomodule Assembly & Test Efforts

Summary from the TTC meeting at Delhi

Tug Arkan

ILC08 - SCRF Meeting

November 17, 2008

Outline

- XFEL:
  - Cryomodule R&D status at DESY
  - Module Assembly Planning at Saclay
- STF at KEK:
  - Next talks by N. Ohuchi and S. Noguchi
- NML at FNAL:
  - CM1 status, CM2 plans
- TTC talks are at the below url:

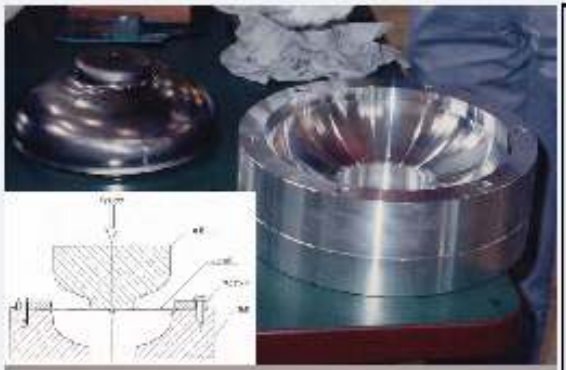
https://indico.desy.de/conferenceOtherViews.py?view=standard&confId=946

XFEL Module R&D at DESY

- Status XFEL: talk by Hans Weise
- 100 accelerator modules

- 800 accelerating cavities (1.3GHz, 23.6 MV/m)

XFEL cavity fabrication

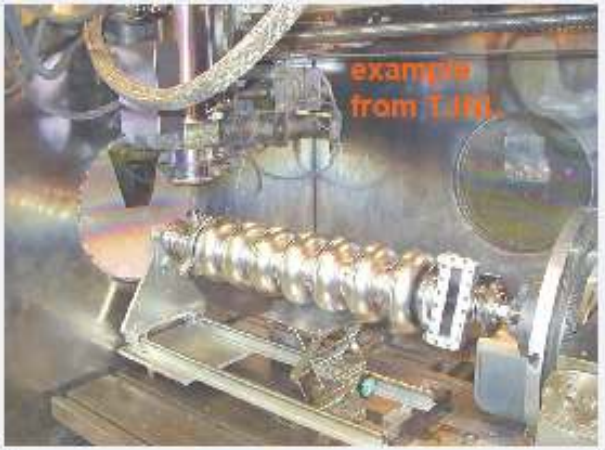


Half cells are produced by deep drawing.

Annealing is next to achieve complete re-crystalisation.

Dumb bells are formed by electron beam welding.

RF measurements support visual inspection.



After proper cleaning eight dumb bells and two end group sections are assembled in a precise fixture.

All equator welds can be done in one production step.

Engineering Data Management Systems (EDMS) is used for the documentation of the cavity fabrication process.

XFEL cavity preparation test cycle

Proposal for minimum cost: One RF Test @ 2K only
Minimum manipulations on CV after 2K test (ready for module assembly)

Final EP:	Flash BCP:
Tuning	**Tuning**
Final EP (40 µm)	**Installation of FMS**
HPR	**TI-cone rings welding**
Installation of FMS	**FM control/ tuning**
TI-cone rings welding	**Tank welding**
FM control/ tuning	**Removal of FMS**
Tank welding	**Flash BCP (10 µm)**
Removal of FMS	**Installation of probes**
Installation of probes	***HOM /Pick Up***
(HOM /Pick Up)	***HQ Antenna (Fixed coupling)***
HQ Antenna (Fixed coupling)	**HPR**
HPR	**120 C bake**
120 C bake	Acceptance test @ 2K
Acceptance test @ 2K	Ready for module
Ready for module	

** FMS= field profile measurement system

Cavity string & module assembly

Using experience gained at DESY and results of industrial studies, the assembly facility for all 100 XFEL modules will be set up at the CEA-Saclay site.

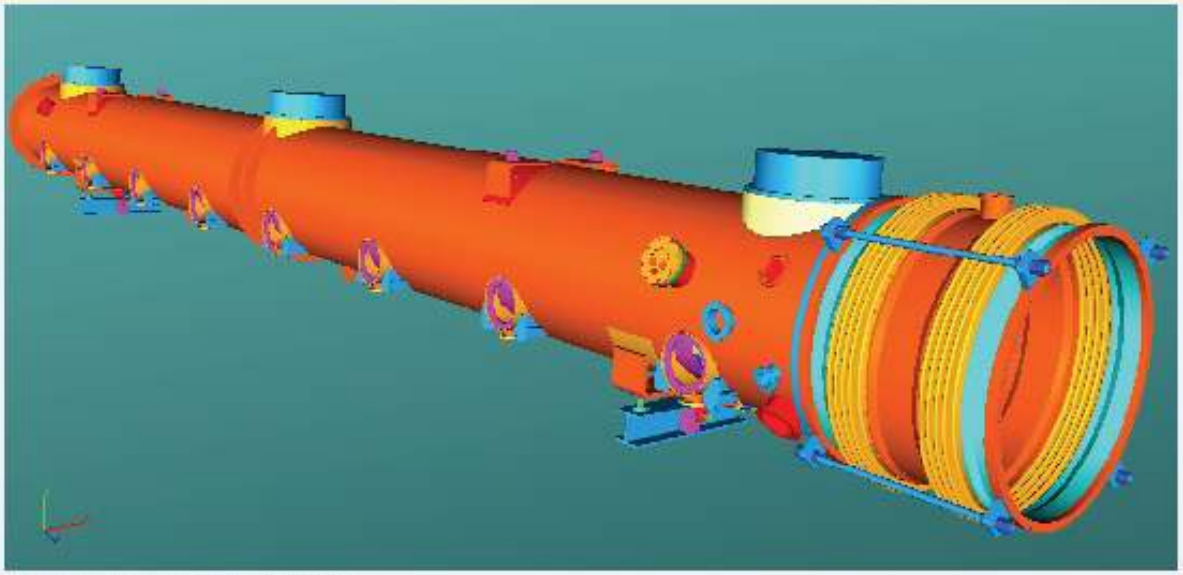
CEA (IRFU), CIEMAT, DESY, INFN-Milano, LAL Orsay, Swierk take the responsibility for the cold linac.

Module Transport Frame

- The Frame is equipped with two **Data Loggers** EnDal Curve 1111
- INFN equipped the Frame and the Module with **additional sensors and** uses **3 geophones** inside of the module (2 on the magnet and 1 on the coldmass' center)
- The INFN electronic will also **readout the vacuum gages** on the beam pipe and coupler pump line and the is permanently checking all RF main input couplers with respect to a short circuit.

More during this TTC meeting / WG2 by Rolf Lange
- ***DESY – CEA Saclay – DESY transport scheduled for week 45***
- ***re-test at CMTB in end of November '08***

XFEL Prototype Cryogenic Modules



One cryomodule each from …

- **Thales / Phoebe (France)** — **delivery expected for December 2008**
- **FCM (Spain)** — **delivery expected for January 2009**
- **IHEP / Aerosun (China)** — **delivery expected for February 2009 (?)**

More during this TTC meeting / WG2
• Cold mass prototyping and industrialization ***Rolf Lange (DESY)***

The European
X-Ray Laser Project XFEL

Tunnel mock-up completed and installations ongoing

High Pressure Vessel Code Test

The European X-Ray Laser Project XFEL

Government of India
Department of Atomic Energy
BHABHA ATOMIC RESEARCH CENTRE

Government of India
Department of Atomic Energy
Raja Ramanna Centre for Advanced Technology, Indore

University of Delhi

High Pressure Vessel Code Test of Module 3*

Hans Weise (for Rolf Lange et al.)

TESLA Technology Collaboration Meeting
New Delhi, October 20th – 23th, 2008

Pressure test of cavity and He vessel

Motivation:
Development of a pressure test for the 800 XFEL cavities as part of a safety acceptance.

- max. possible pressure inside He vessel is 4 bar rel.
- pressure vessel regulations require 4 x 1.43 = 5.72 bar
- pressure test with 1 bar abs. in the cavity requires 6.72 bar, i.e. 7 bar abs. during a test

Goal:
Do the pressure test with water at warm temperature and check for plastic deformation of cavities.

Two cavities were tested:
C26 1350 ºC oven treatment
Z97 800 ºC oven treatment
wall thickness of both cavities is 2.5 mm

Accelerator Module 3* at CMTB

Motivation for the 'destructive' tests

Investigate fault conditions during cryogenic operation of the XFEL modules

Study insulation and beam pipe vacuum system …

- The worst case is a total breakdown of the vacuum systems during the cool down operation at XFEL:
  - The thermal shields pipes are under maximum pressure
  - The cavity are completely filled with liquid He at 4.3 – 4.5K (1.1 – 1.3bar)
- What happens if the same event occurs under steady state operation at 2K/31mbar?
- Possible faults are:
  - Venting of the beam pipe from the connection in the cryo boxes
  - Venting of the insulation vacuum from the connection in the cryo boxes – DN 100
- Detailed report published by B. Petersen:
  - *"EXPERIMENTAL TESTS OF FAULT CONDITIONS DURING THE CRYOGENIC OPERATION OF A XFEL PROTOTYPE CRYOMODULE "*, International Cryogenic Engineering Conference ICEC22, July 2008, Seoul/Korea

M3* test sequences

In total 8 tests were carried out on module 3* at CMTB:

- Test 1 – **slow venting isovac.** with He (He-leak) - 2K operation
- Measurement: cavity performance and cryo loses / Max. pressure isovac.: 10E-5mbar up to 2 mbar
- Test 2 – **slow venting coupler vac.** with N2 - 2K operation
- Measurement: cavity performance. and cryo loses / Max pressure coupler vac. < 600 mbar
- Test 3 – **slow venting beam pipe vac.** with N2 – 2 K operation
- Measurement: cavity performance and cryo loses / Max. pressure beam pipe vac. 6*10E-6 mbar
- First warm up 300K and cool down again:
- Test 4 and 5 – **fast venting isovac.** with air – 2 K operation
- Second warm up to 300K (repair He-leak 2K-area / isovac) and cool down again:
- Measurement: cavity performance and cryo loses
- Test 6 – **fast venting beam pipe vac.** with air – 2 K operation
- Third warm up to 300K and cool down again
- Measurement: cavity performance and mech. detuning of cavities
- Test 7 – **fast venting beam pipe vac.** with air – 4,5 K operation
- Measurement: cavity performance and mech. detuning of cavities
- Test 8 – **fast venting isovac.** with air – 4,5 K operation
- Measurement: Diff.-pressure isovac. / Temp. development of vac.vessel

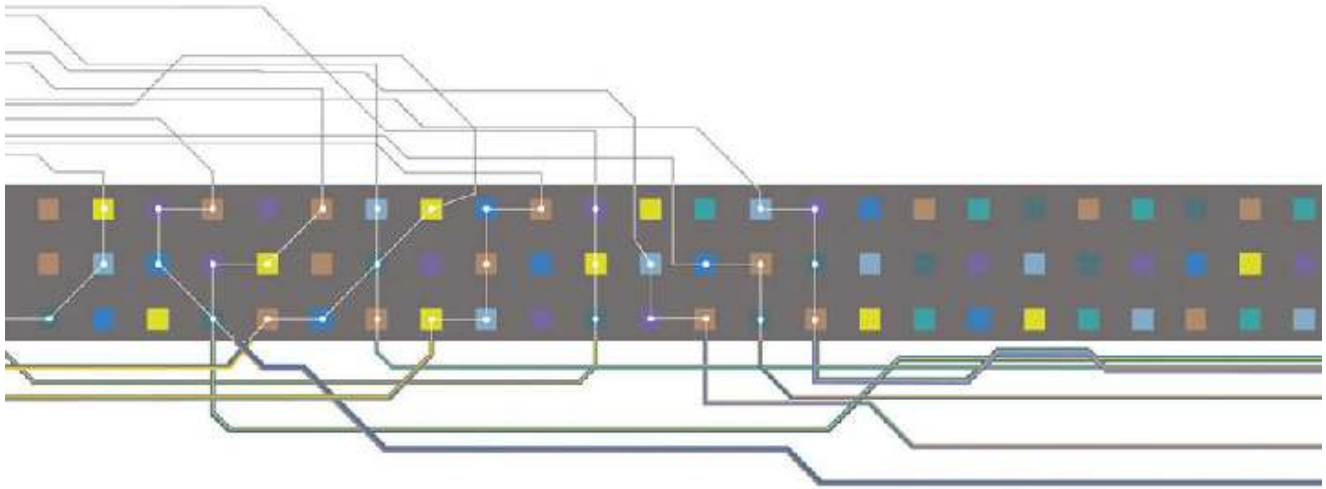
- End of M3* test at CMTB – M3* disassembled to check for damage

Conclusions

- The calculated values of pressure drops in the He-circuits during venting the beam pipe and insulation vacuum are confirmed
- The cavities' frequency and field flatness was unchanged
- A venting of the beam pipe seems to be "relaxed" because the blast wave needs 3.6 sec over one single accelerator module, i.e. there is sufficient time to close gate valves
- After a venting of the insulation vacuum followed by pump down (no warm-up) the module was operated under 'normal' conditions (rf and cryo-wise)
- The frequency tuners' drive system still works
- The venting of an XFEL unit's (12 modules) insulation vacuum is much more relaxed as compared to the CMTB test because the volume is factor ~12 larger, i.e. the pressure blast less critical
- The deformation of the XFEL module's 70K shield is more relaxed because the expanse of the thermal shield is smaller then for the tested Type II module
- *The contact of the coupler antennas is **not understood** !!???!!!??!!!!*

Module Assembly at Saclay

THALES



Preliminary Industrialisation Studies of XFEL Cryomodules

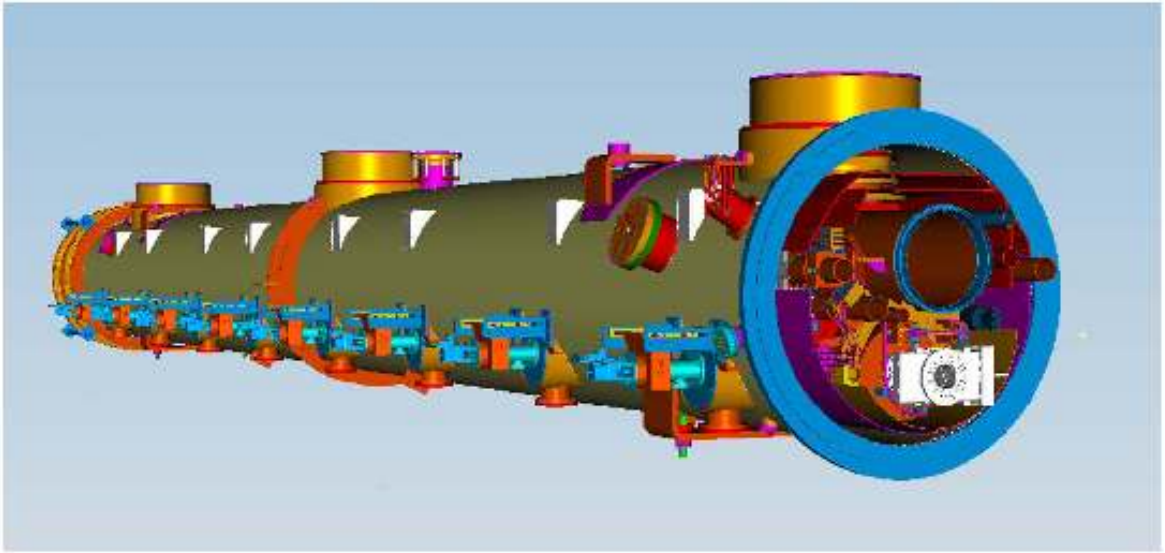
C. Liguoro, J.P. Brasile (Thales)
J. Caseiro, P. Heine (Phoebe),
S. Berry, S. Chel, A. Daël, C. Madec and O. Napoly (Cea-Saclay)

22/10/08

Land & Joint Systems

XFEL EPI: preliminary industrialisation study

Thales was contracted by CEA for preparing an industrialization study for the XFEL cryomodules assembly in the site of Saclay (France)



Our aim is to add to the CEA technical knowledge our industrial know how capabilities

XFEL EPI: preliminary industrialisation study

The production organisation has to achieve the following objectives:

- Assembly of one cavity string (8 cavities) per week
- Delivery of one cryomodule per week
- A Global production of 100+3 cryomodules with:
  - A ramp up with 3 pre-series
  - A traceability of each part of the module and safe data management,
  - Some partial electrical measurement
  - Leak checks and measurements of critical quotes
  - The respect of ISO14001 (environmental standard) procedure

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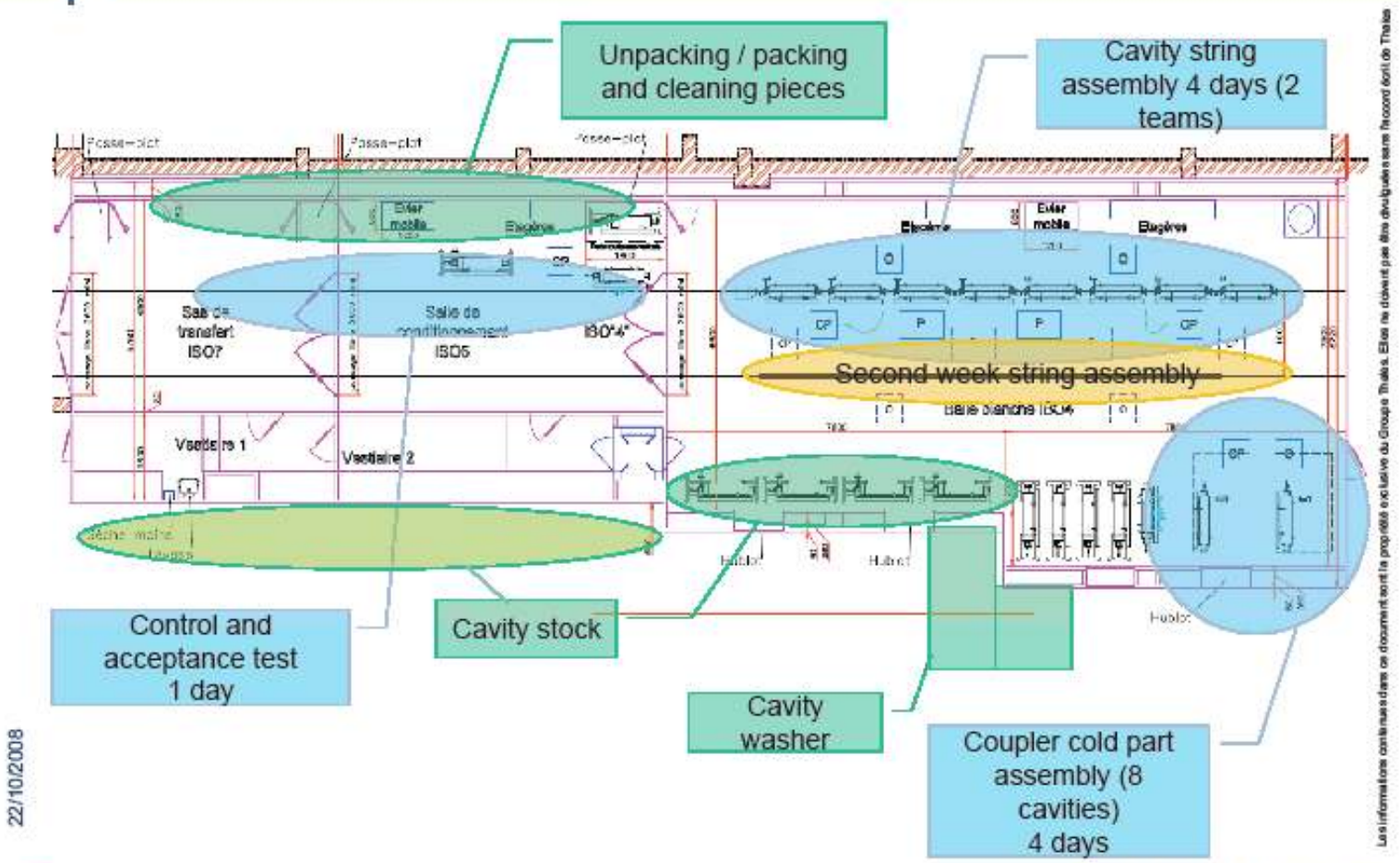
XFEL CEA Saclay Infrastructure Plans



THALES

XFEL production challenge

Our risk analyses lead to following issue of XFEL module assembly:

- The difficulty to identify and fix a discrepancy
  - Target: a zero default production
  - ➢ The importance of the Quality Plan & Procedure.
  - ➢ Well trained team
- Assembly of critical sub-systems coming from different places with a configuration to manage.
  - Many data to exchange
  - Rigorous configuration management
  - ➢ Importance of the ERP
- The short lead time of production
  - A cryomodule to deliver per week
  - ➢ 2 Shifts organisation

22/10/2008

FNAL Module Activities

- CM1 is assembled with the assistance of DESY colleagues. It is currently being installed at NML for testing.
- CM2 cavities are being tested in VTS. Cavity Dressing is planned to start in January 2009 and HTS to follow. CM2 tentative assembly schedule: Late summer 2009
- CM3 will be probably the first Project X prototype cryomodule (beta=1). It is currently under design.
- Project X beta=0.8 cryomodules will be designed by RRCAT in India. Components will be fabricated at Indian Industries. Modules will be assembled at CAF.

Pictures from CM1 String Assembly at CAF-MP9

Pictures from CM1 Assembly at CAF-ICB






CM1 Transport

- The CM1 assembly traveled 2.1 miles in 50 minutes with an average speed of 2.6 mph
- The maximum acceleration on cold the cold mass was: vertically=0.4 g, transverse=0.36 g and longitudinal=0.13g

Summary of CAF Activities

- CAF infrastructure is fully operational for R&D rate module assembly and cavity preparation for VTS & HTS. We need to assess the upgrades necessary for Project X assembly throughput requirements (1 module / month)
- 3.9GHz module assembly will likely start in January 2009:
  - Cavities are currently being dressed and tested in HTS
  - All the components (except the cavities) are ready for module assembly (stored at CAF)
  - Assembly travelers are ready
  - Module engineering documentation is complete and waiting for review & approval process
  - Expected shipping time frame to DESY: February-March 2009
- CM2 parts will be sent by INFN as a kit except dressed cavities and string related components:
  - Cavities are currently being tested at VTS
  - Helium Vessel welding & dressing will start in January 2009
  - CM2 assembly is planned to start late summer to early Fall 2009