Technology Transfer and Relations with Industry

Industrialization of Superconducting Accelerator Module Production

Bernd Petersen DESY MKS

acting for the European XFEL-Project Cold Linac Accelerator Consortium
material provided by Catherine Madec, Olivier Napoly (CEA Saclay), Hans Weise DESY

EPAC08, Genoa, Italy, June 23-27, 2008

Outline

Industrialization of sc cryomodule production may be arranged in different phases:

Phase 1 Design and prototyping - already in view of industrial production

Phase 2 Extensive testing of prototypes –feedback to design

Phase 3 Review of prototype design and assembly by industrial studies – special issues included

Phase 4 Prototype call for tender – test of specs

Phase 5 Matching of procedures with the final fabrication site

The European XFEL-Project

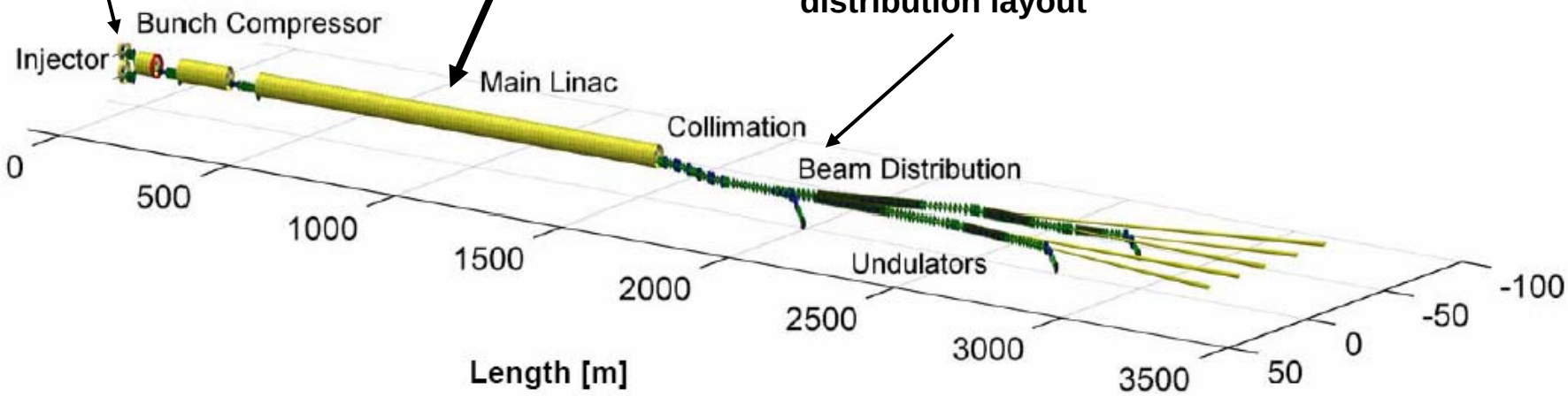
A superconducting linac (TESLA technology) will be built as a driver for the X-ray Free Electron Laser

17 GeV electron beam energy

One injector initially installed

101 cryomodules required

Connection to 2nd stage upgrade included in beam distribution layout



Phase 1 (1) -> suited design: sc TESLA modules

About 20 years ago: idea to build a 500 GeV superconducting linac

The only chance to be competitive:

Cavity accelerating fields >= 25 MV/m to make the linac short enough

Low static and dynamic (Qo > 5*10**10) cryogenic loads

Long (2.5 km) identical cryogenic units of simple structure

Long ‚cheap' accelerator modules designed for ‚easy' assembly in industry (in view of the industrial production of 2000 modules)

->INFN Milano TESLA cryomodule design

in co-operation with ZANON company (Italy)

(TTF-type I) 8 sc 1.3 GHz cavities + sc Quad

Phase 2 (1): proof of principle & extensive testing

FLASH = **F**ree Electron-**LAS**er in **H**amburg -> **Complete XFEL Project system test**

History : TESLA Test Facility -> TTF1-linac -> TTF/FEL-VUV-linac -> FLASH

Installation of module 6 during 2007 shut-down

Like FLASH itself the cryomodules fulfill ‚multi-purpose' functions:

- FLASH operation
- development for XFEL-linac
- development for FEL-light sources (BESSY FEL, EUROFELdesign)
- development for TESLA and now International Linear Collider (ILC)

Industrialization of FLASH modules = Industrialization of XFEL modules

Phase 2 (2): feedback to design

TTF type II : re-design of thermal shields (M1,2,3,7)

TTF-type III: cavities & couplers fixed by invar rod support

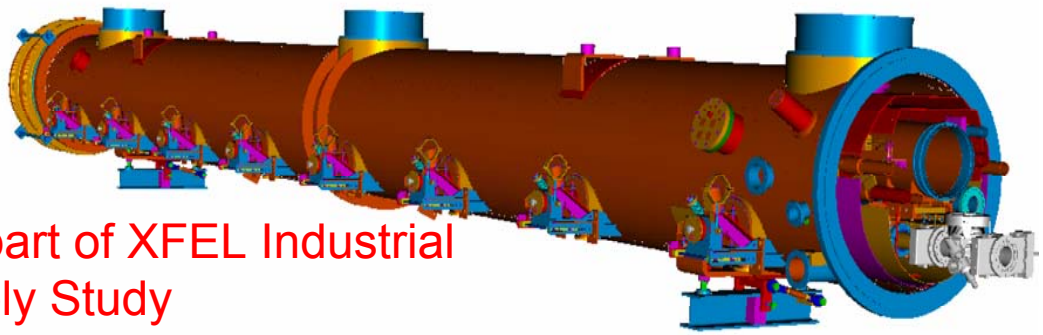
vacuum vessel diameter standard industrial size

(M 4,5,**6**)

XFEL/TTF-type III plus : Quad 2K cooled, integrated in cavity support

(FLASH kompatible) (M**8**,9)

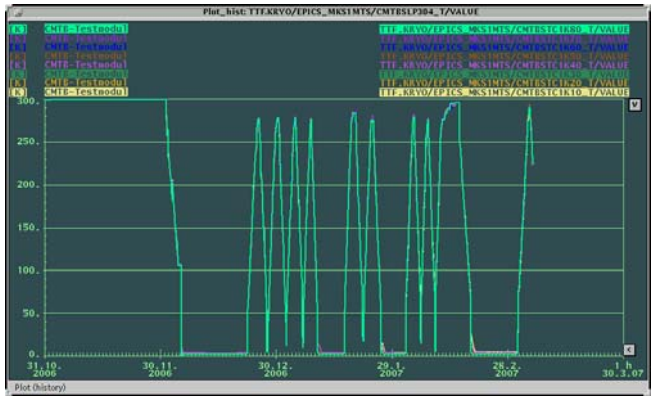
XFEL-prototype : cavity distances meet N*λ/2 (ERL-option)



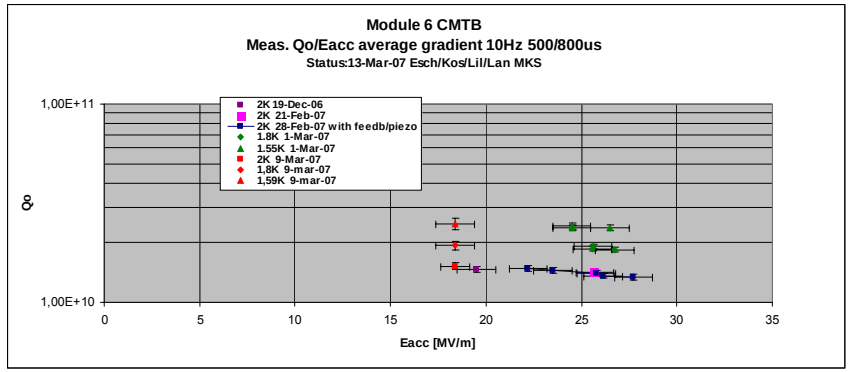
Modules 6 & 8 part of XFEL Industrial Module Assembly Study

Phase 2 (3): extensive testing on test bench

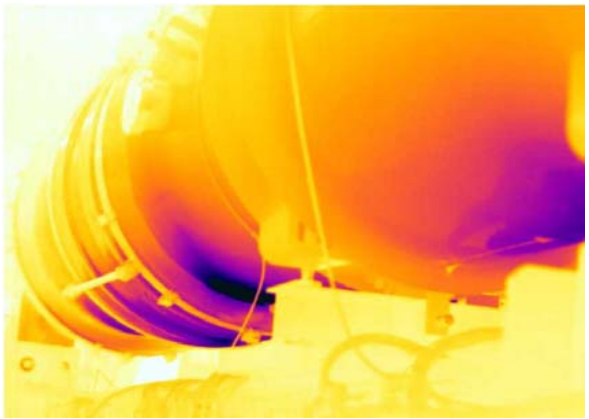
Phase 2 (4): extensive testing – at the limits



Thermal cycling (M6)



RF Cavity performance



Vacuum venting (M3*)

Phase 3 (1): Industrial Studies - TESLA-TDR

For the TESLA technical design report industrial studies were launched

Objectives of these studies:

Investigations of module production costs and production rates

Scenario of industrial production of 2000 modules

These investigations were based on fixed laboratory assembly ‚recipes.'

Later added: scenario for the production of only about 100 TESLA-cryomodules for the XFEL-project

Phase 3 (2) : XFEL-cryomodule industrial studies

For the preparation of the serial production of about 100 cryomodules for the European XFEL-Project, industry should be involved as soon as possible:

> ***EUROFEL Design Study DS6 contract No 011935***
> Preparation of the **European XFEL-Project** and other superconducting linac based FEL-light sources like the **BESSY FEL**

Formal difficulties:

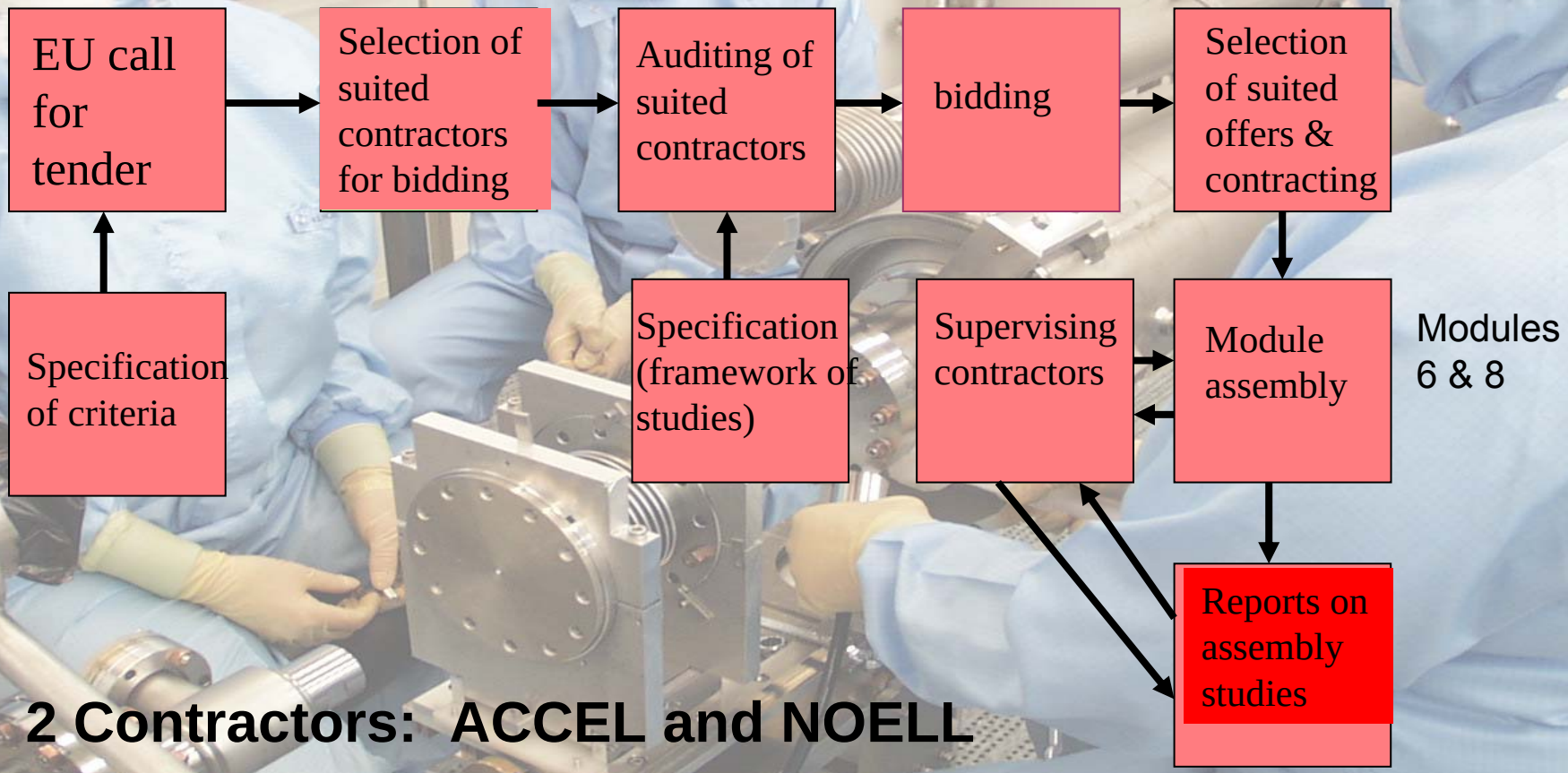
In the preparatory phase DESY was (and is still) acting for the future XFEL company but could not (and will not) start call for tenders for the final XFEL cryomodules.

Industrial cryomodule design & assembly studies were decoupled from the final call for tenders.

To ensure equal treatment for the final call for tender, the technical results of the assembly studies were published.

Assembly Studies: Procurement Procedures

21.01.2005



2 Contractors: ACCEL and NOELL

FINISHED 2007

ACCEL Cryomodule Assembly Study I

S. Bauer, B. Griep, M. Pekeler, H. Vogel, J. Zeutschel
ACCEL Instruments GmbH
Friedrich-Ebert-Str. 1
51429 Bergisch Gladbach

BILFINGER BERGER
Power Services

BABCOCK NOELL

Industry Study on the Series Production of XFEL Cryomodules

C.Boffo, W. Gärtner, S. Sattler, G. Sikler, U.-M. Tai

Phase 3 (3): XFEL cryomodules industrial studies

Experts from industry follow the whole assembly procedure of two prototype cryomodules at DESY

Active **role of industry during the assembly of module 8 !**

Objectives:

The present cryomodule assembly procedures and some aspects of the present design shall be analyzed and questioned with respect to the most cost effective serial production.

Key aspects of the study:

- Analyze the assembly procedure
- Analyze the final design of the modules
- Define cost-reduction measures
- Define performance improvement measures
- Supply a cost estimate for the module production

Phase 3 (4)XFEL Industrial Cryomodule Assembly Studies: results

General results on the cryomodule assembly study:

- general assembly procedures are suited for industrial serial production of 100 modules
- no general changes concerning the assembly are necessary
- transport of modules can be handled

Production of one module per week is possible if

- a redundant production line in the clean room is built
- qualtiy inspection is improved
- cleaning of individual parts is sourced out

Phase 3 (5) Some results from the Industrial Studies -> Improvements

Clean room assembly:

‚Generally the procedure and the assembly steps of the string assembly inside the clean room seem to be well advanced. The good performance of the cavities after module assembly demonstrates this.‘

Simpler tools for faster alignment of cavity string

Fixed bellows flanges (tighter cavity tolerances)

Cleaning of components sourced out

Assembly outside clean room:

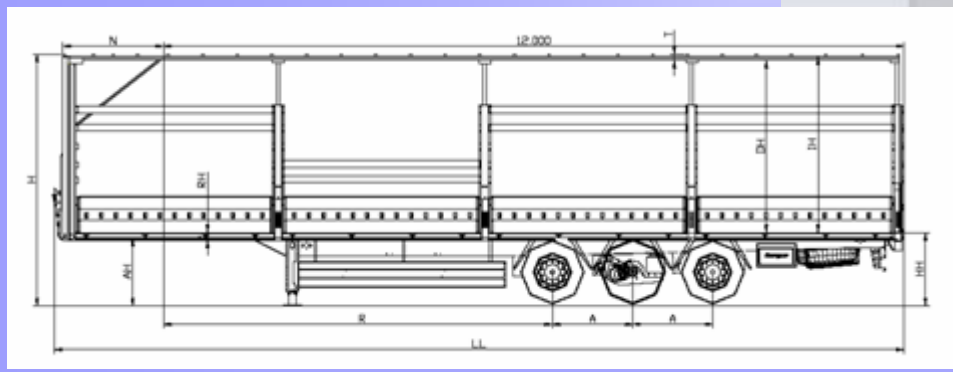
‚Generally the procedures and the assembly steps used during the module assembly outside the clean room are well advanced and only slight modifications are necessary for XFEL series production.‘

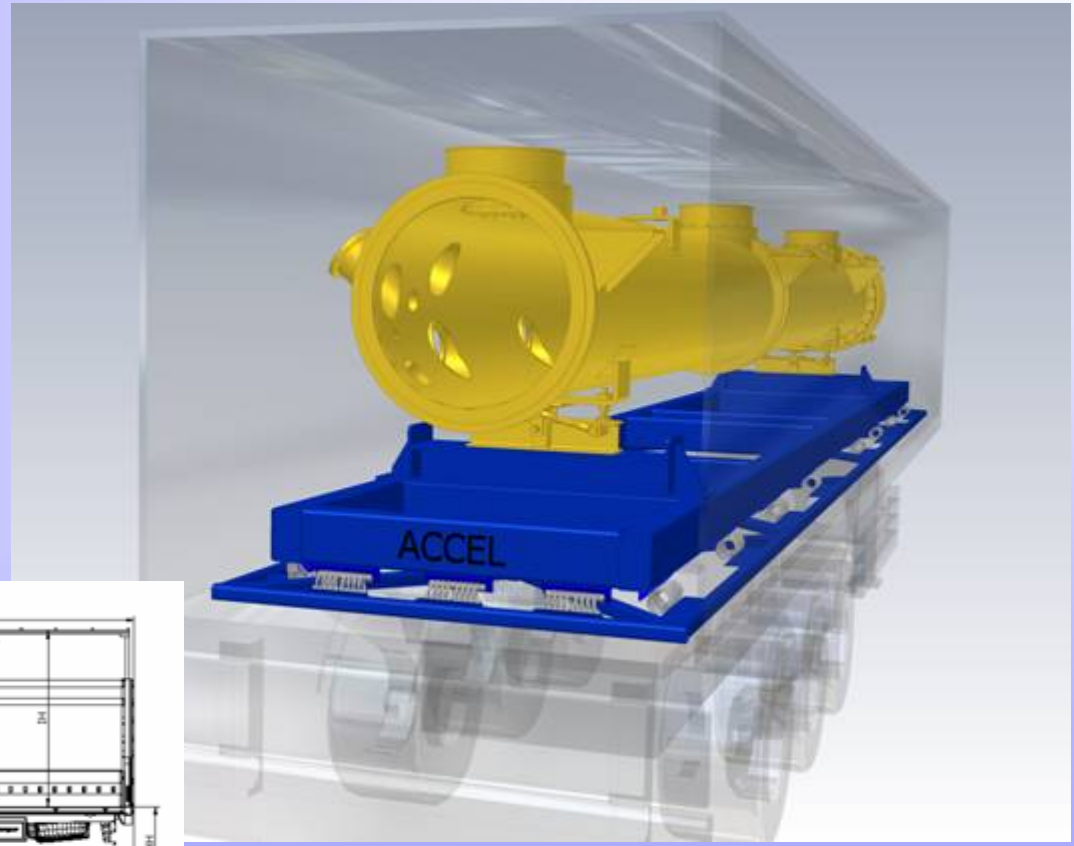
Improvement of cold mass alignment/ cavity string to cold mass

Larger vacuum vessel diameter recommended

possible solution for XFEL module transports

- transport frame is mounted on truck
- truck can be loaded with crane from top
- truck travels between assembly site and XFEL site
- available length: 13.6 m
- available width 2.5 m
- available height: 2.5 m
- allowable weight: 12 t





Caution: top loaded road semi trailer hard to find outside EU. In US only hard cover or flat bed trucks (weather impact) available.

CM Transport
Cavity System I

BABCOCK NOELL

Which component is most critical?

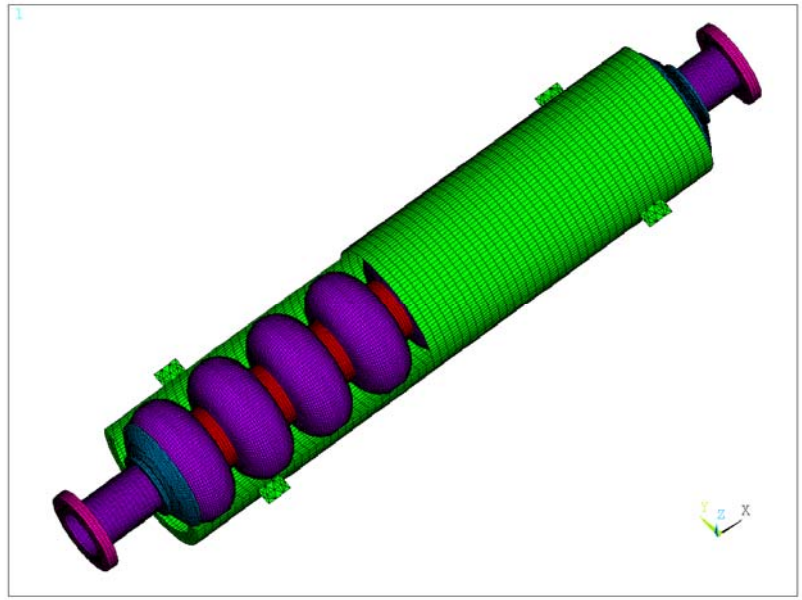
What is the maximal tolerable acceleration?

Determine for the typical modes of excitation :

- Zones of largest stress
- Pressures within the material
- Bending amplitudes (position and size)

-> Finite-element representation of the cavity system is necessary.

CM Transpo
Cavity Systen



Which component is most critical?
What is the maximal tolerable acceleration?

Determine for the typical modes of excitation :

- Zones of largest stress
- Pressures within the material
- Bending amplitudes (position and size)

-> Finite-element representation of the cavity system is necessary.

Phase 3 (6) Industrial Studies -> Issues to be considered

Issues to be considered:

There was an extensive information transfer between the experts from industry and the laboratory experts already during the preparation of the study and during the assembly work- beside the ‚official' documents.

The personal communication and the direct demonstration of clean room assembly details are imperative for an effective knowledge and skills transfer. Even very complete protocols can not replace the direct communication.

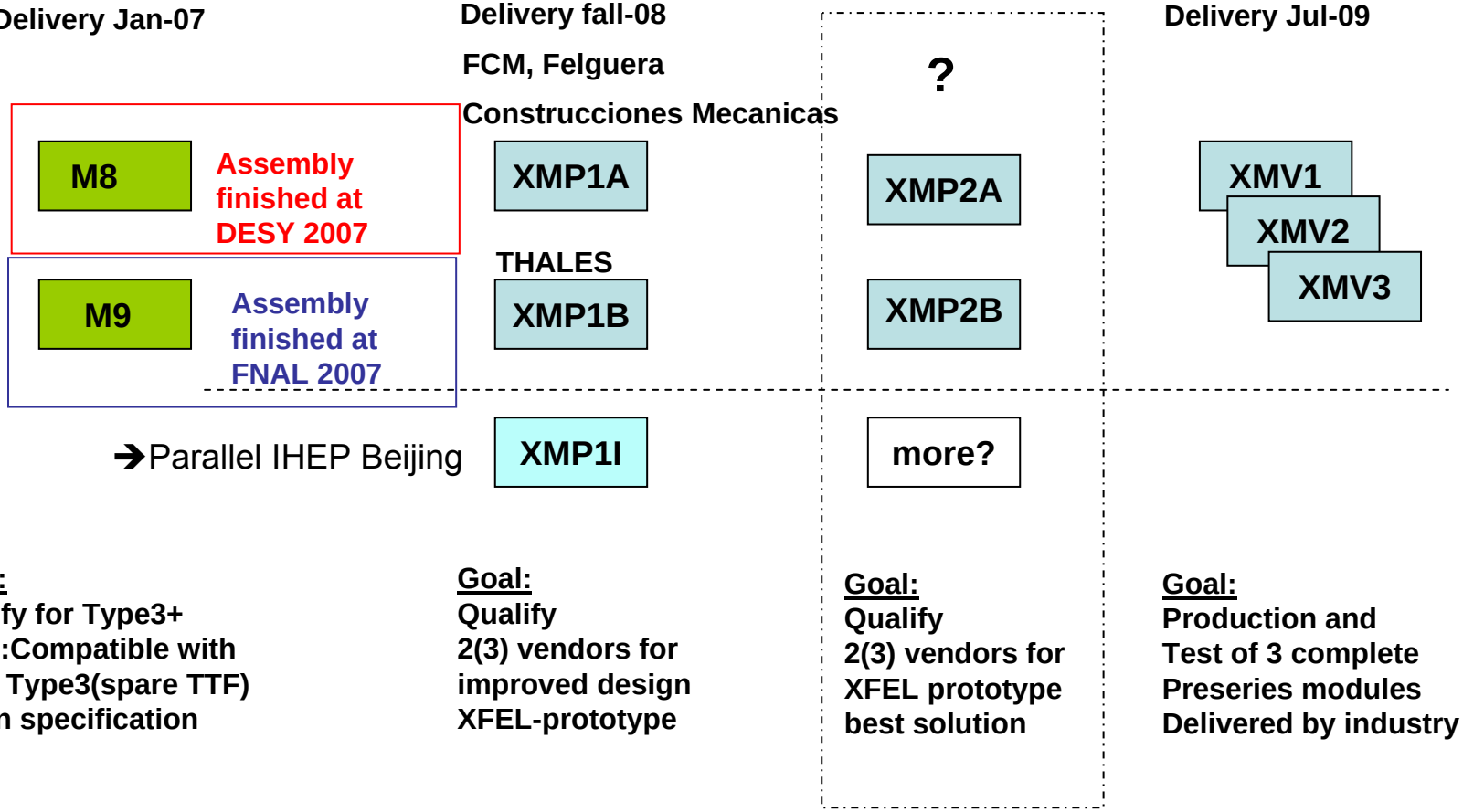
The active role of industry during the assembly of module 8 showed how transfer was received.

Phase 4 (1) : Prototype (cold-mass) call for tender

Order at Zanon Dec-05
2 cryostats
cold mass/vac-vessel
Delivery Jan-07

Call for tender ->Order at A, B
2 +1cryostats
cold mass/vac-vessel
Delivery fall-08

Order at ? (Sep-08)
3 Pre-cryostats
complete modules
Delivery Jul-09



Goal:
Modify for Type3+
Must:Compatible with
Type3(spare TTF)
Learn specification

Goal:
Qualify
2(3) vendors for
improved design
XFEL-prototype

Goal:
Qualify
2(3) vendors for
XFEL prototype
best solution

Goal:
Production and
Test of 3 complete
Preseries modules
Delivered by industry

Phase 4 (2) Pressure Vessel Code Qualification

For the approval to operate the XFEL-linac

a ‚Certificate of Conformity' (to the european pressure vessel guidlines) is required for the XFEL-modules

-> the european harmonized rules have to be applied

-> the cold linac is treated as a single pressure vessel

-> TUEV-Nord (german third party authority) has been put in charge to prepare a general procedure for the design and construction of the modules (‚Baumusterzulassung')

-> report expected 9/2008

Internationalization of XFEL 'cold-linac' (DESY Proposal)

WP 01: Power RF	DESY & RU
WP 02: LLRF	DESY & Lodz
WP 03: Module	CEA & DESY & INFN
WP 04: Cavities	DESY & INFN
WP 05: Coupler	DESY & LAL
WP 06: HOM	DESY & Swierk
WP 07: Tuner	DESY & INFN
WP 08: Cold Vacuum	DESY & BINP
WP 09: String Assembly	CEA & DESY
WP 11: Cold Magnets	CIEMAT & DESY
WP 46: 3.9 GHz	DESY & INFN

Phase 5 (1) Matching with the final fabrication site

Industrialization of XFEL module assembly at CEA/Saclay

- ***Goals of the preliminary industrialization study (EPI)***

Define the infrastructure :

- **Current infrastructure**
- **Foreseen infrastructure**

Establish Fabrication folder (fill-in assembly steps sheet, labour …)

Analyze the risks :

- **Infrastructure, manpower, utilities, test equipments, tooling, training etc**

Define tooling

Establish the financial report

Phase 5 (2) Matching with the final fabrication site

Dec 07 : CEA placed an order for a Preliminary Study for industrialization of CM assembly to Thales

Jan 08 : Preliminary Study for industrialization of CM assembly Kick off

Feb 08 : Choice of the infrastructure

Sept 08 : End of the study

Summary

Industrialization of sc cryomodule production
can be arranged in different phases:

Phase 1 Design and prototyping - already in view of industrial production

Phase 2 Extensive testing of prototypes –feedback to design

Phase 3 Review of prototype design and assembly by industrial studies – special issues included

Phase 4 Prototype call for tender – test of specs

Phase 5 Matching of procedures with the final fabrication site

Acknowledgments

I want to thank the involved experts from ACCEL and Babcock NOELL companies for the excellent and valuable work for the industrial studies.

Thanks to my colleagues from INFN, Saclay, BESSY and DESY !

Thanks to the EUROFEL Design study contract No 011935

for the support !

THANK YOU !