France Contribution to the XFEL Project

Presentation of the
XFEL Cold Linac Consortium

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The XFEL Project

in short

XFEL: the accelerator

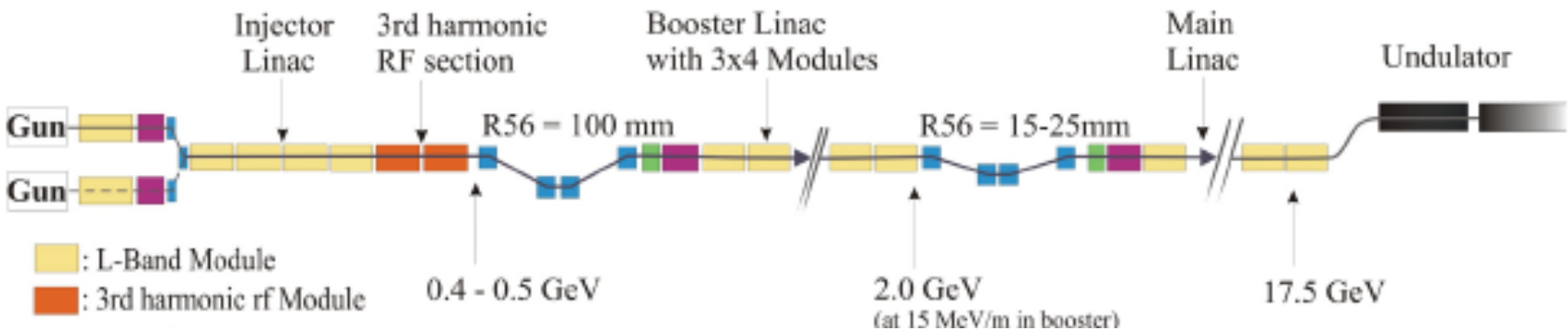
Final energy 17.5 GeV (instead of 20 GeV)

RF Gun + 1 cryomodule + 25 RF units (10 MW, 4 cryomodules, 32 cavities)

+ (1) x 4 x 8 x 12,5 MeV → 500 MeV

+ (2+1) x 4 x 8 x 23.6 MeV → 2 GeV

+ (20+1) x 4 x 8 x 23.6 MeV → 17.5 GeV

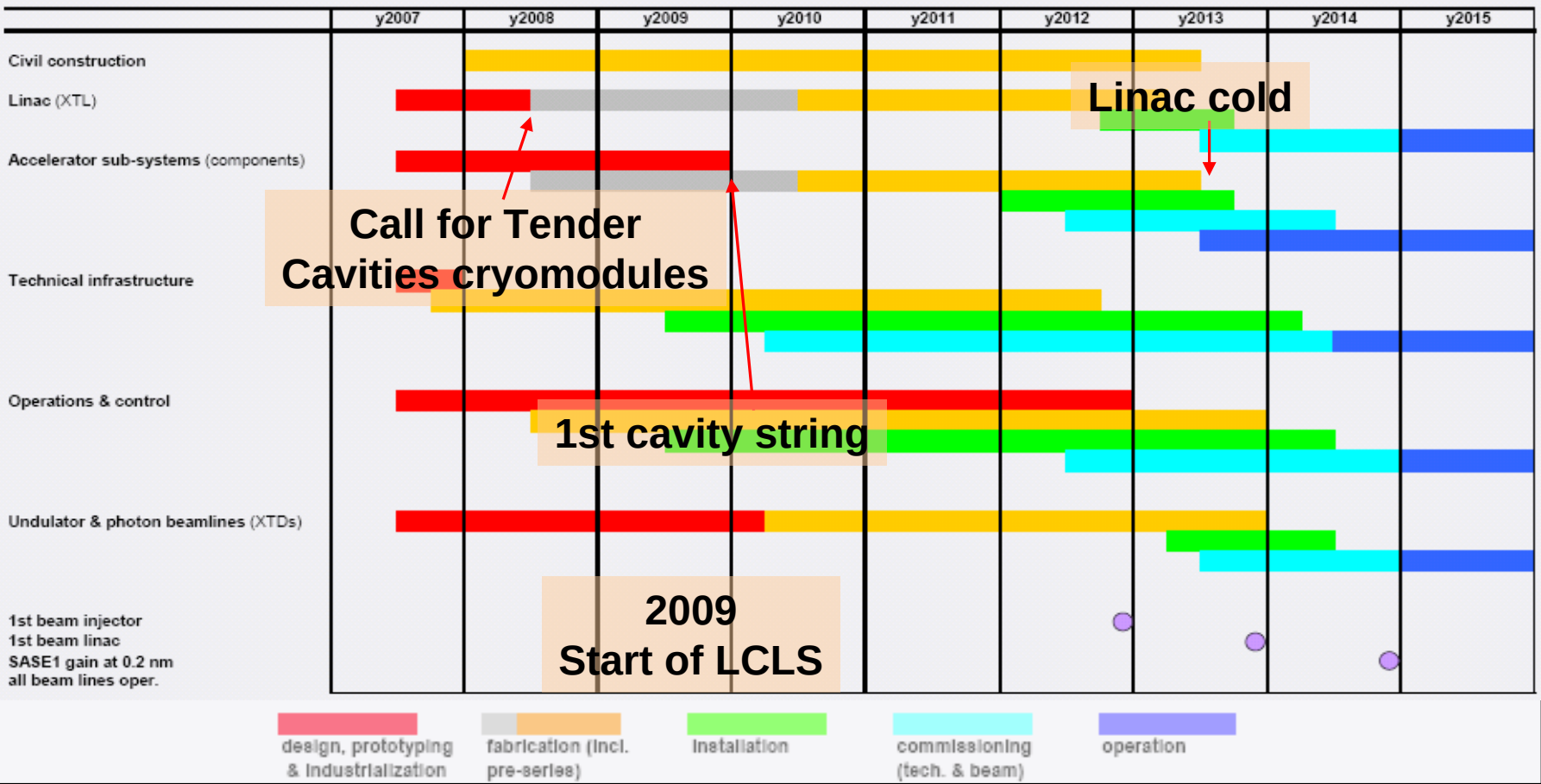


Total: 25 Klystrons, 101 modules, 808 Cavities

including 2 RF units (64 cavities) for spare

XFEL : Schedule

- We have the overall schedule promising first beam through the linac before end of 2013; this schedule can be used to determine earlier project milestones



XFEL: Work Packages

Group 1: Linac	01 RF System	02 Low Level RF	03 Acc. Modules
	04 SC Cavities	05 Power Coupler	06 HOM Coupler
Cold Linac	07 Frequency Tuner	08 Cold Vacuum	09 Strings
	11 Cold Magnets		
Group 2: Accelerator Subsystems	12 Warm Magnets	14 Injector	15 Bunch Compress.
	16 Lattice	17 Stand. Beam Diagn.	18 Spec. Beam Diagn.
	19 Warm Vacuum	20 Beam Dump	Cold BPM
Group 3: Photon Beam Lines	21 Undulators	22 Hard Photons	23 Medium Photons
	24 Photon Diagnostic	25 Experiment Areas	26 Detector Developmt
	27 FEL Concepts		
Group 4: Control and Operation	28 Control Systems	29 Operability	35 Radiation Safety
	36 General Safety	38 Personnel Interlock	39 EM Interference
Group 5: Infrastructure	10 Module Test Facility	13 Cryogenic	32 Survey
	33 Tunnel Installation	34 Utilities	
Group 6: Site and Buildings	31 Site and Civil	37 Plan Approval	

XFEL Cold Linac : Accelerating Modules

Superconducting Cavity (23.4 MV/m)

Clean Room Assembly

8-Cavity string with RF Couplers

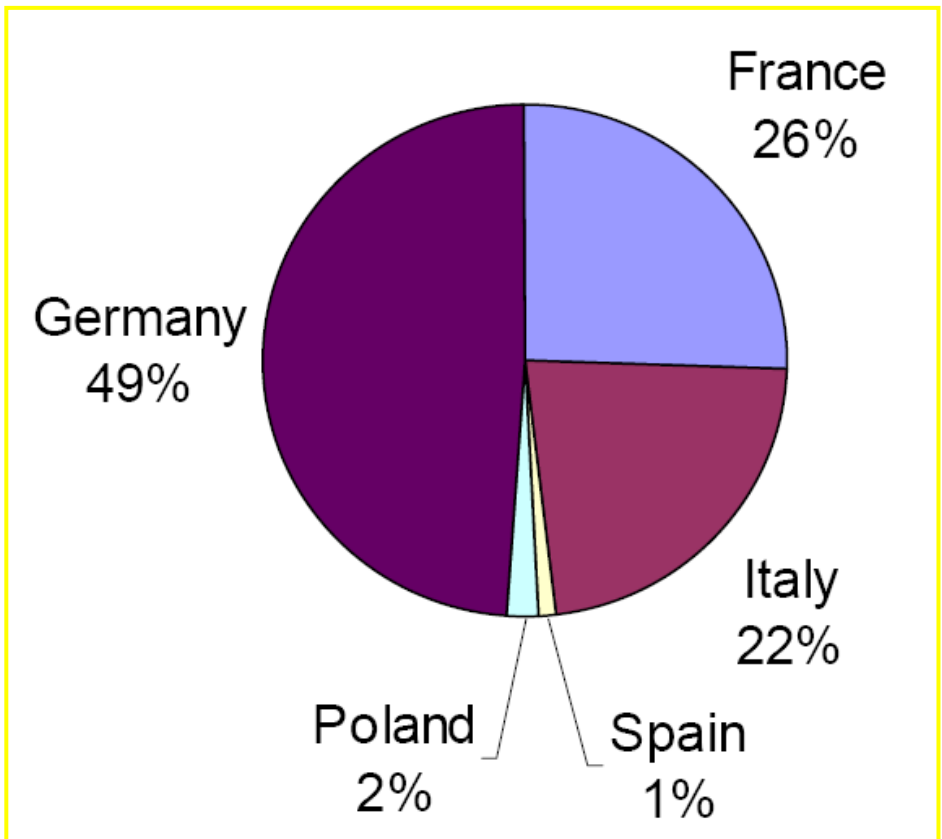
Cavity string under Cold mass

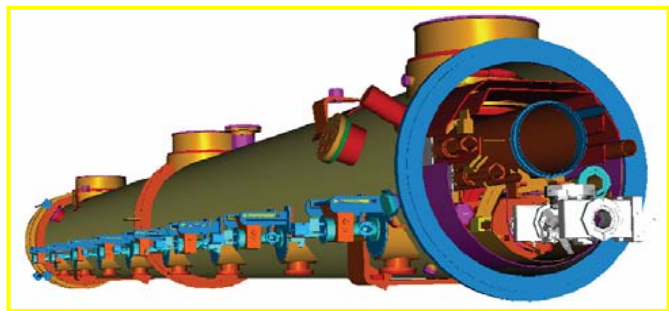
Vacuum vessel and cantilever

Cryomodule in tunnel

XFEL Cold Linac Consortium

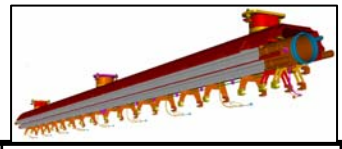
- DESY, INFN, CEA and IN2P3 will be the major in-kind contributors of the XFEL Cold Linac components





Estimated distribution of the In-Kind contributions to the XFEL Cold Linac

XFEL Cold Linac Consortium





	Cryomodule Fabrication	Cryomodule Assembly	Cavities / couplers	Clean Room Assembly
DESY	25 %	-	50 % cavities	Participation to supervision
INFN	25 %	Participation to supervision	50 % cavities	-
CEA IRFU-Saclay	50 %	100 % + couplers/warm	-	100 % + couplers/cold
IN2P3 LAL-Orsay	-		100 % couplers	

Coarse grain distribution of In-Kind Funds and Responsabilities

- This distribution of responsibilities is approved by the XFEL project management, the “In Kind Review Committee” and the “International Steering Committee”

The XFEL Coupler Production

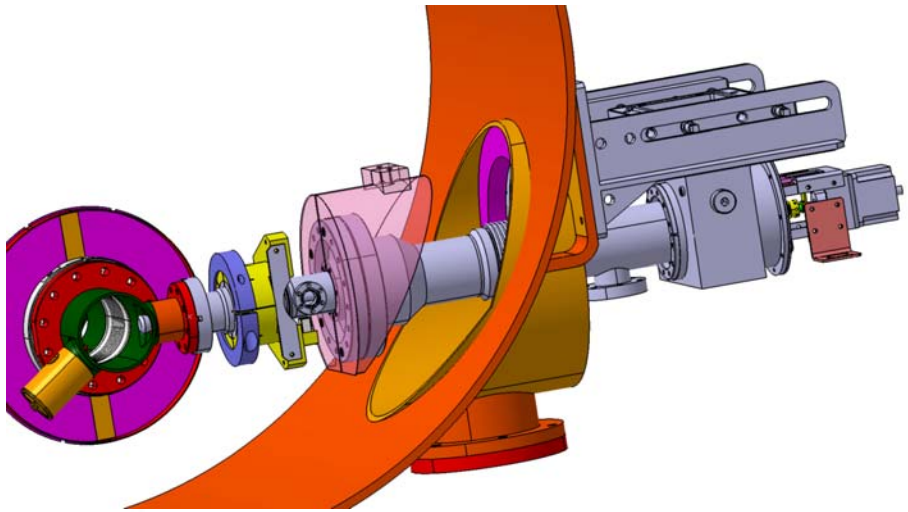
by LAL-Orsay

IN2P3
Institut National de Physique Nucléaire et de Physique des Particules

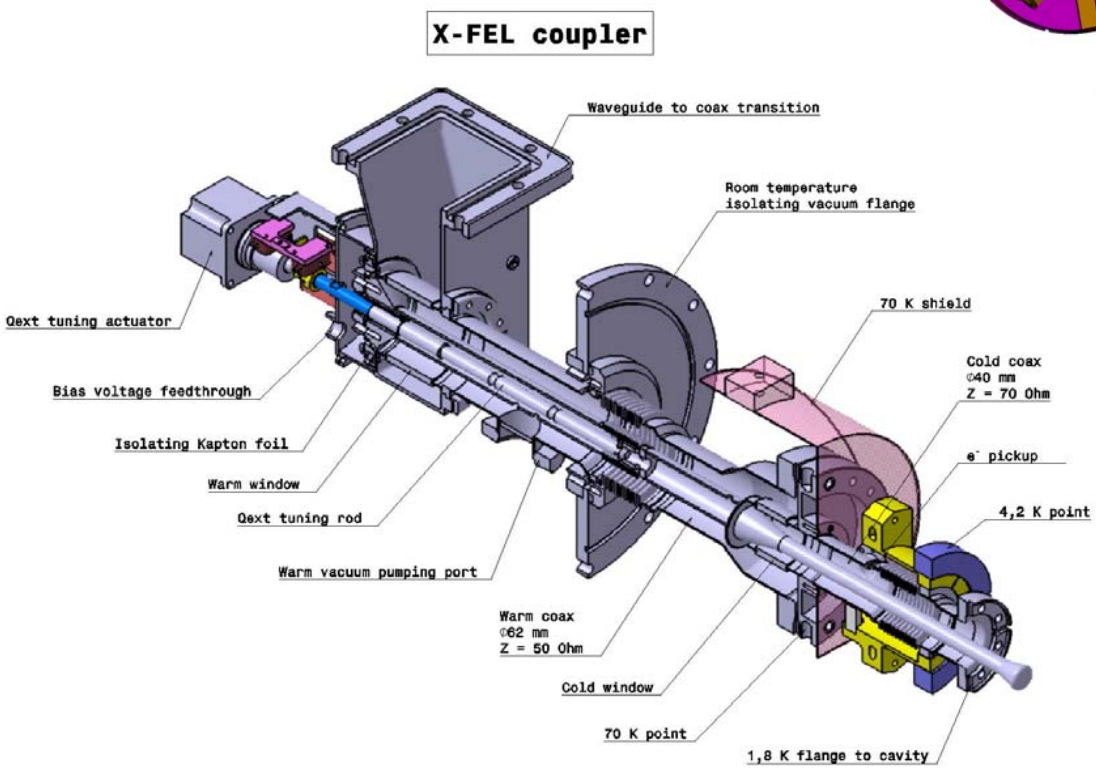
XFEL
X-Ray Free-Electron Laser

In the frame of the French contribution to **XFEL** project,

LAL is in charge of "in-kind" delivery of 832 input couplers



Input coupler on cryomodule



3 Main difficulties:

- Industrial production of coupler parts
- Assembly in clean room
- RF conditioning

Expertise required from industry in the couplers production

EB welding

Vacuum brazing

TiN coating th. ~ 10nm

Precise geometrical tolerances

Surface finish
and cleanliness

TIG welding

Cu plating: 10 < RRR < 100

Motorized tuning

EN 1.4435

EN 1.4429

Special austenitic stainless steel

+ He leak rate < 10^{-10} Pa.m3/s
+ Careful Handling with gloves
+ Assembly in clean room
+ RF Conditioning

1 - LAL conducted industrialization studies to clarify the mass production of couplers

Award of 3 contracts in March 06: ACCEL, e2v, TOSHIBA

System Design Review:

- functional analysis

Preliminary Design Review:

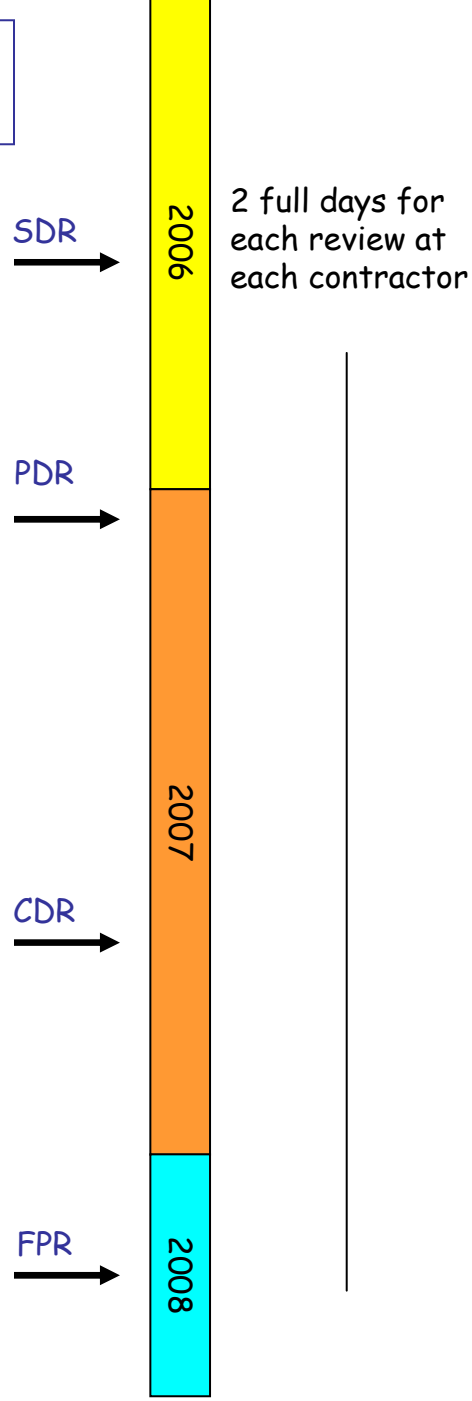
- feasibility of the manufacturing processes
- samples for parts and joining

Critical Design Review:

- detailed drawings
- organization of the mass production
- risks analysis
- samples of Cu plating and TiN coating

Final Project Review:

- deliver 2 prototypes
- volume manufacturing plan
- costs estimate for XFEL couplers

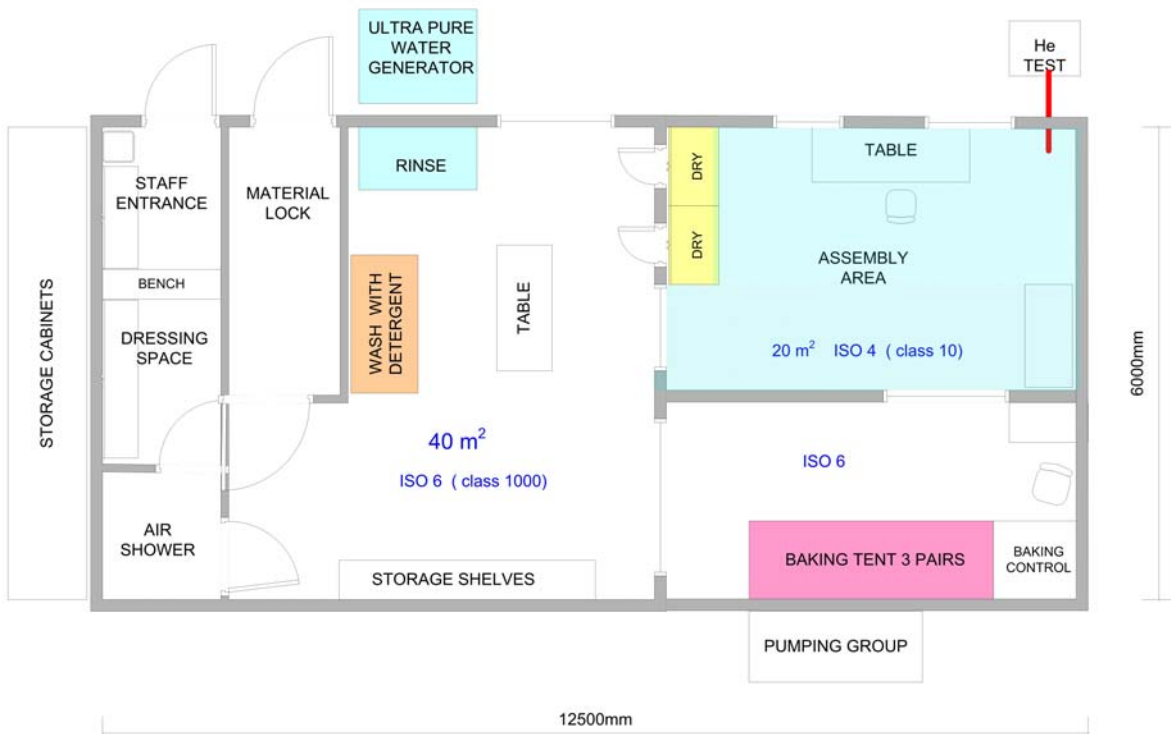


2 - LAL has gained experience in Assembly and Conditioning

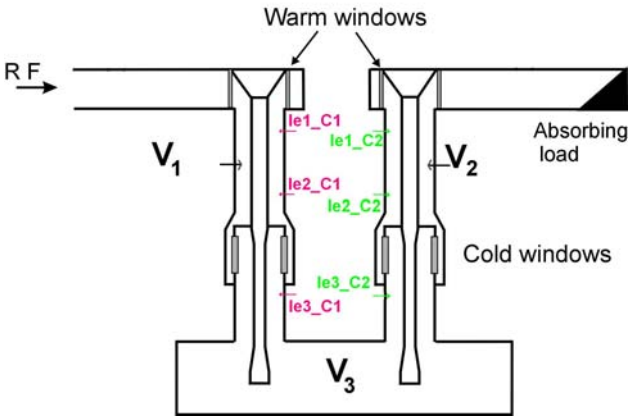
Test station at LAL, sized for 50 couplers /year:

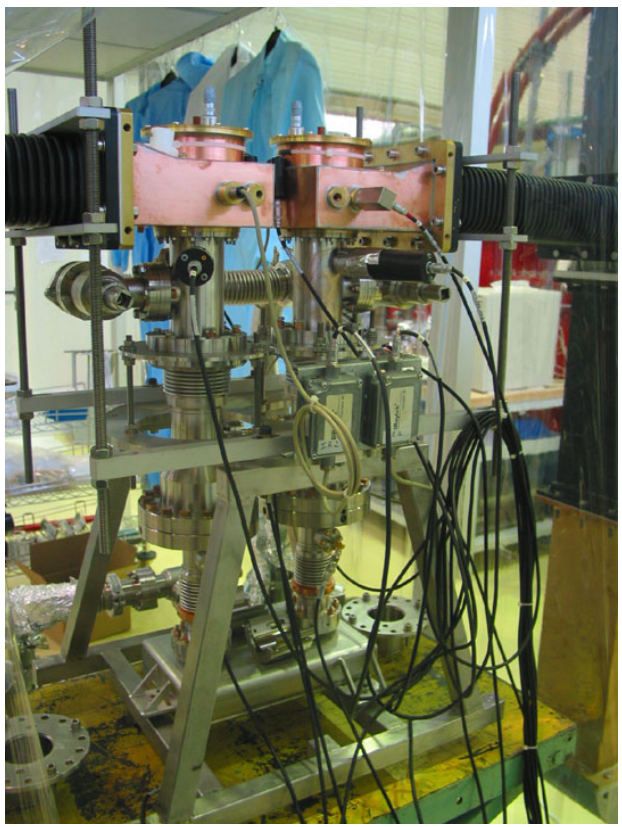
- clean room with 2 zones:
  - class 1000: wash and rinse
  - classe 10: dry, bake, assemble
- RF Modulator and 5 MW Klystron

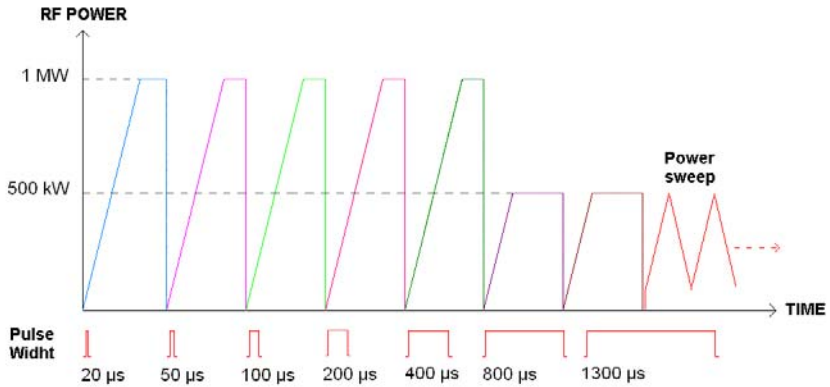
Project of Clean room layout for 200 couplers / year

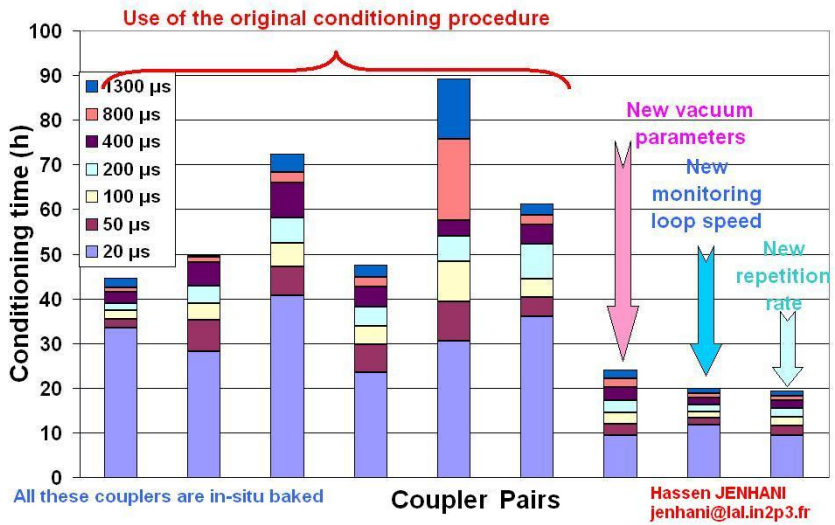


3 - LAL has been working several years to optimize the RF conditioning time







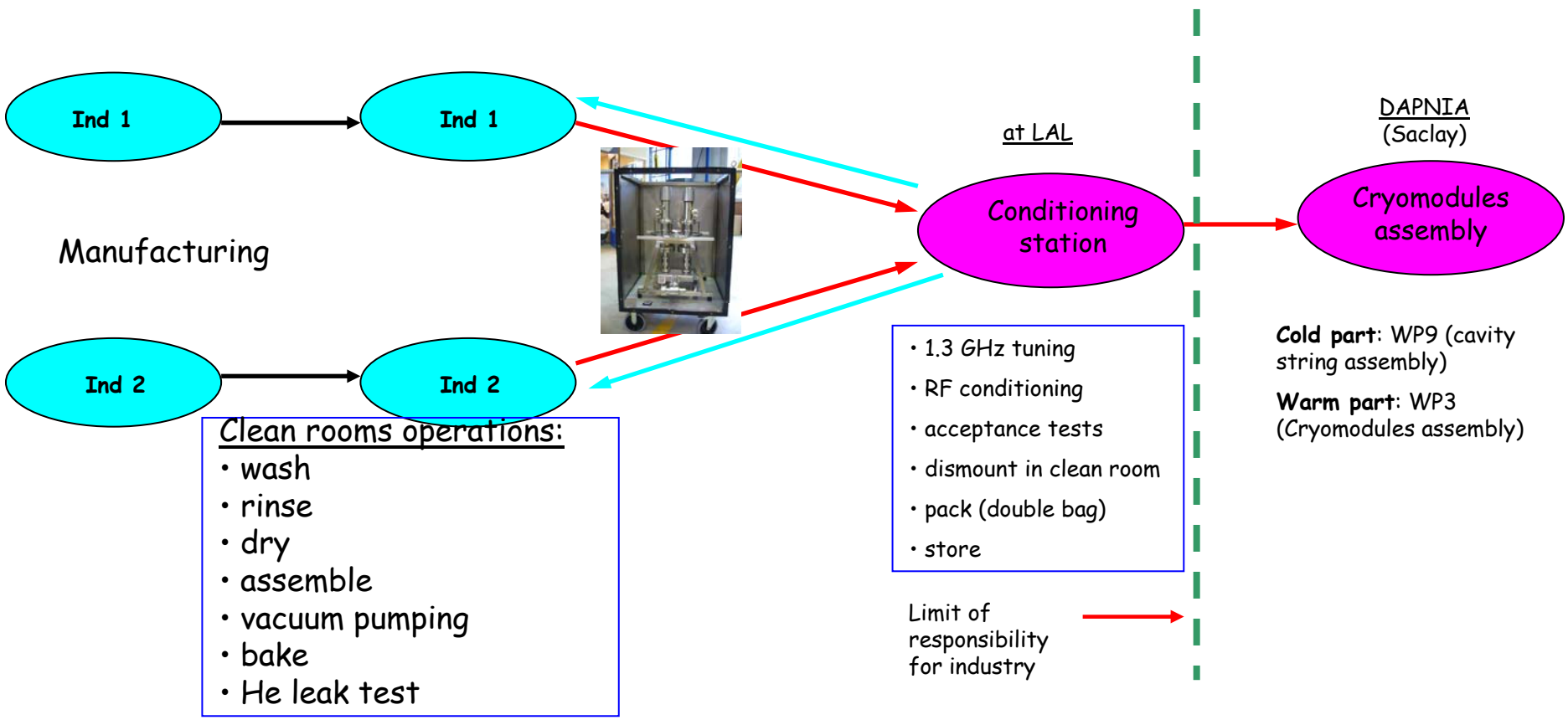


Now: Total duration for conditioning + tests → 40h / pair if OK

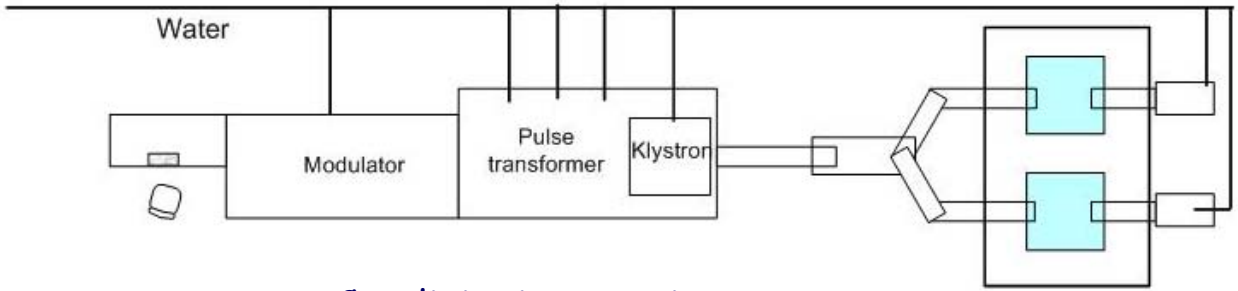
Scenario for couplers production – WP5 of XFEL project

Principles:

- 2 industrial contracts: each for 416 couplers + (n/2) spares
- Production and assembly in specific clean room at each industry
- Responsibility of industry includes RF conditioning
- RF conditioning: 1 single station at LAL



Necessary infrastructure at LAL for XFEL couplers



Conditioning station

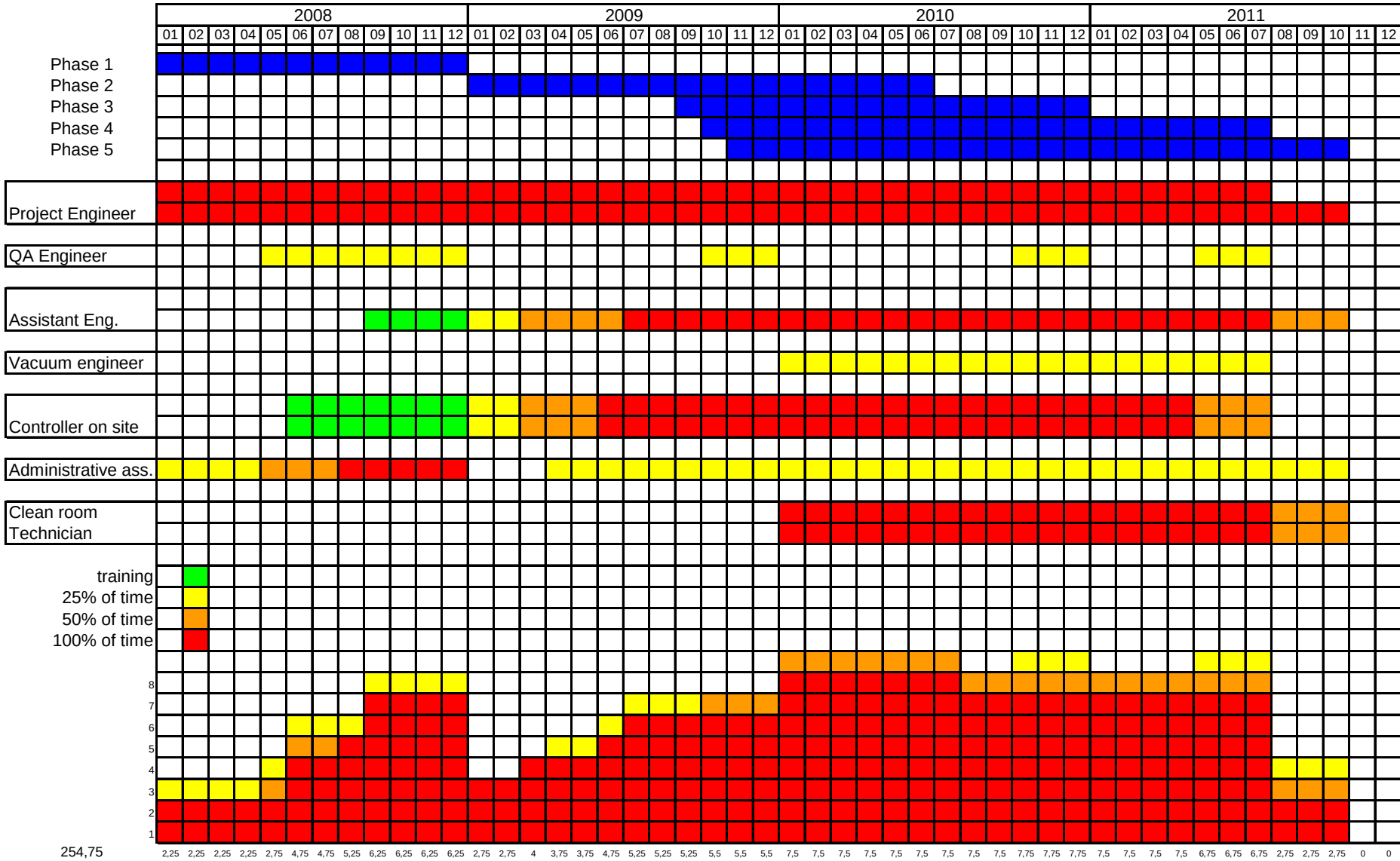
40 m² Clean room for:

- dismounting warm & cold parts from test stand
- packing in double bags filled with N2
- treatment of couplers which failed conditioning

Storage space:

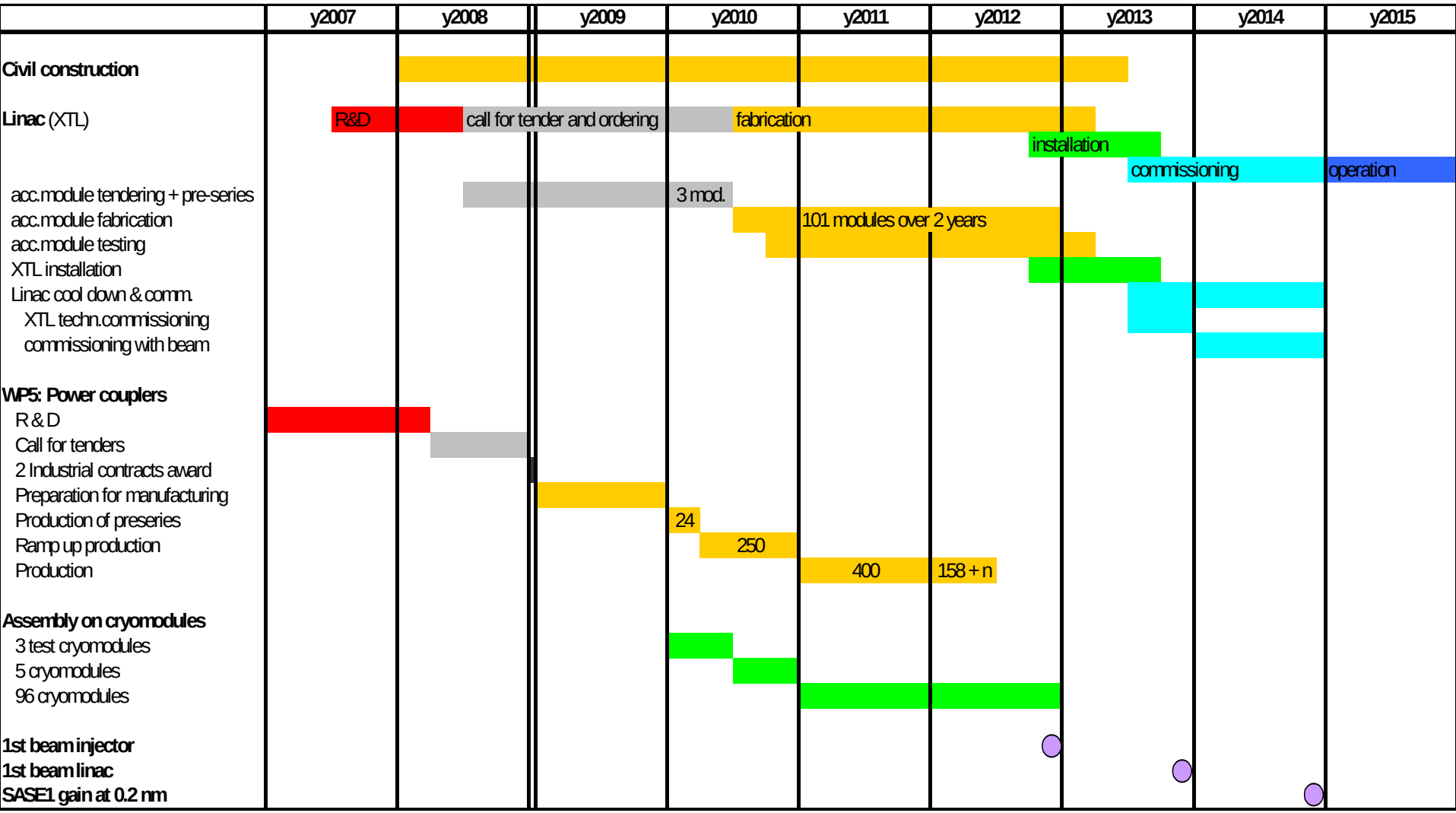
- shelves for 200 couplers
- prepare to deliver batches to DAPNIA

Personnel resources (LAL) for XFEL power couplers project



FTE : 255 / 12 = 21,2 man x year

WP5 Interface with Linac schedule



Number of couplers:

- for test cryomodules: 24
- for Linac: 808
- spares: n

The XFEL Cryomodule Production at CEA-Saclay

Cryomodule Production Plant

Project motivation:

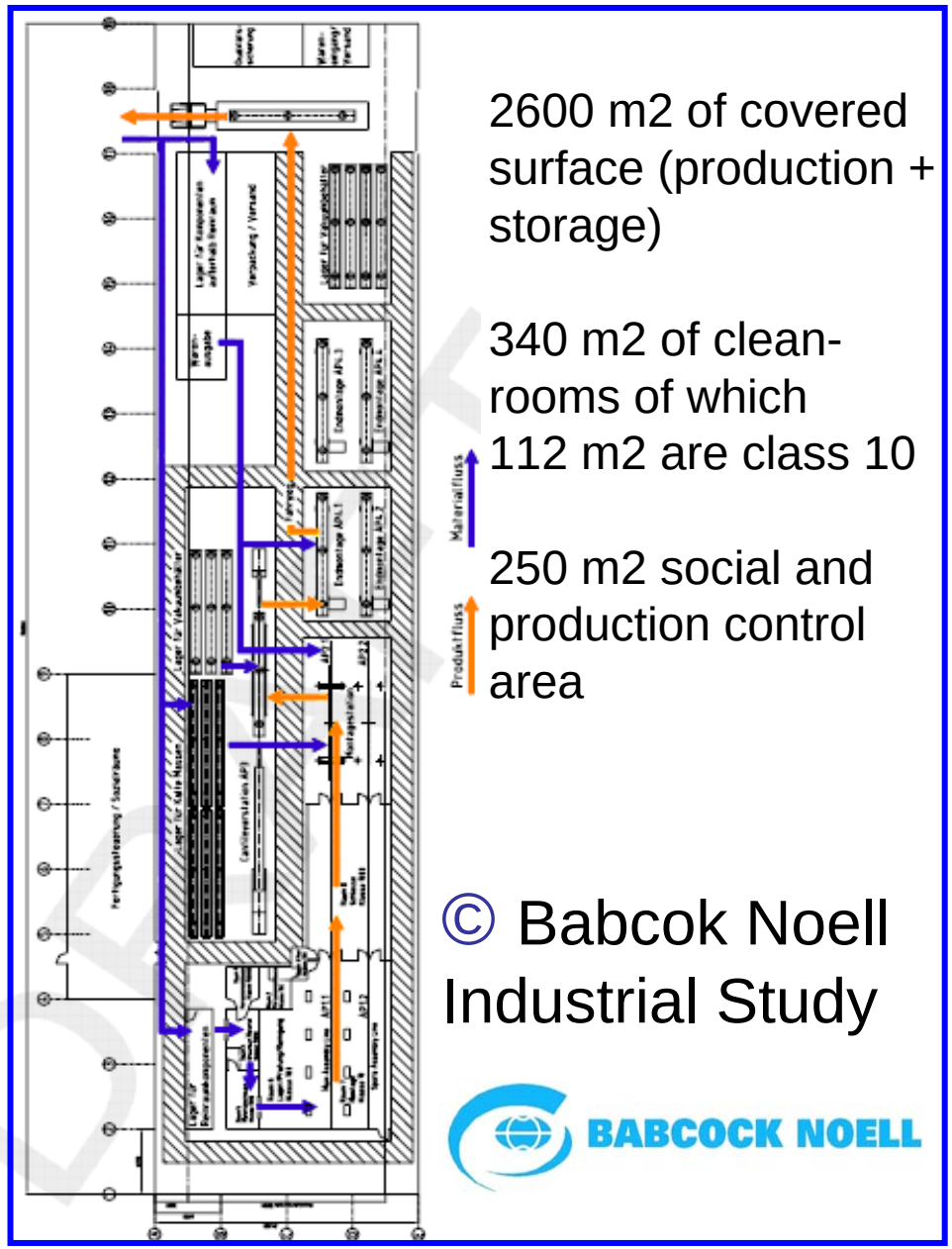
a **unique** cryomodule production plant is favored by the XFEL Management to save the cost of the Clean Room and Integration Halls.

CEA motivation:

Saclay will host this infrastructure in the pre-existing SATURNE hall complex, in synergy with

a) moving the late 80's "MACSE" SCRF clean room

b) SPIRAL2 SCRF needs.



2600 m2 of covered surface (production + storage)

340 m2 of clean-rooms of which 112 m2 are class 10

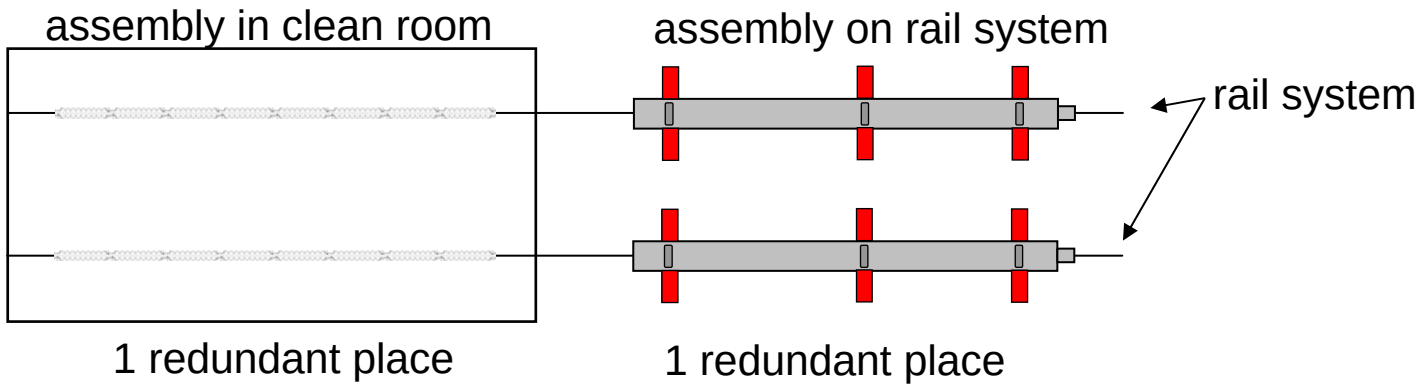
250 m2 social and production control area

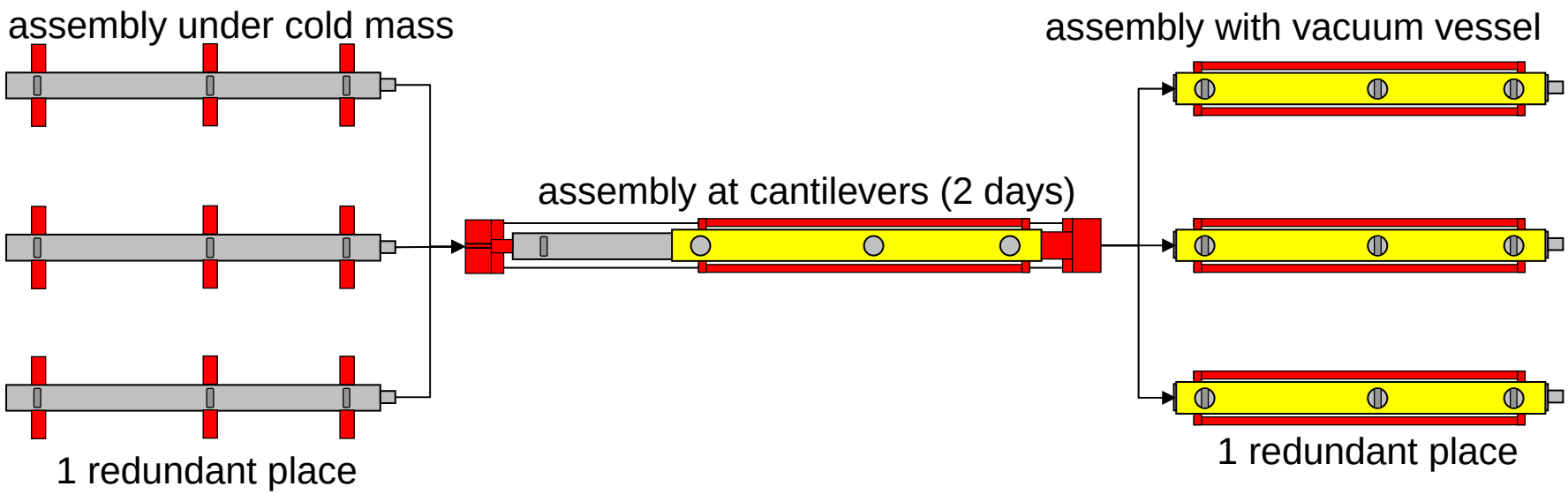
© Babcok Noell Industrial Study

BABCOCK NOELL

Infrastructure requirement: 1 module/wk

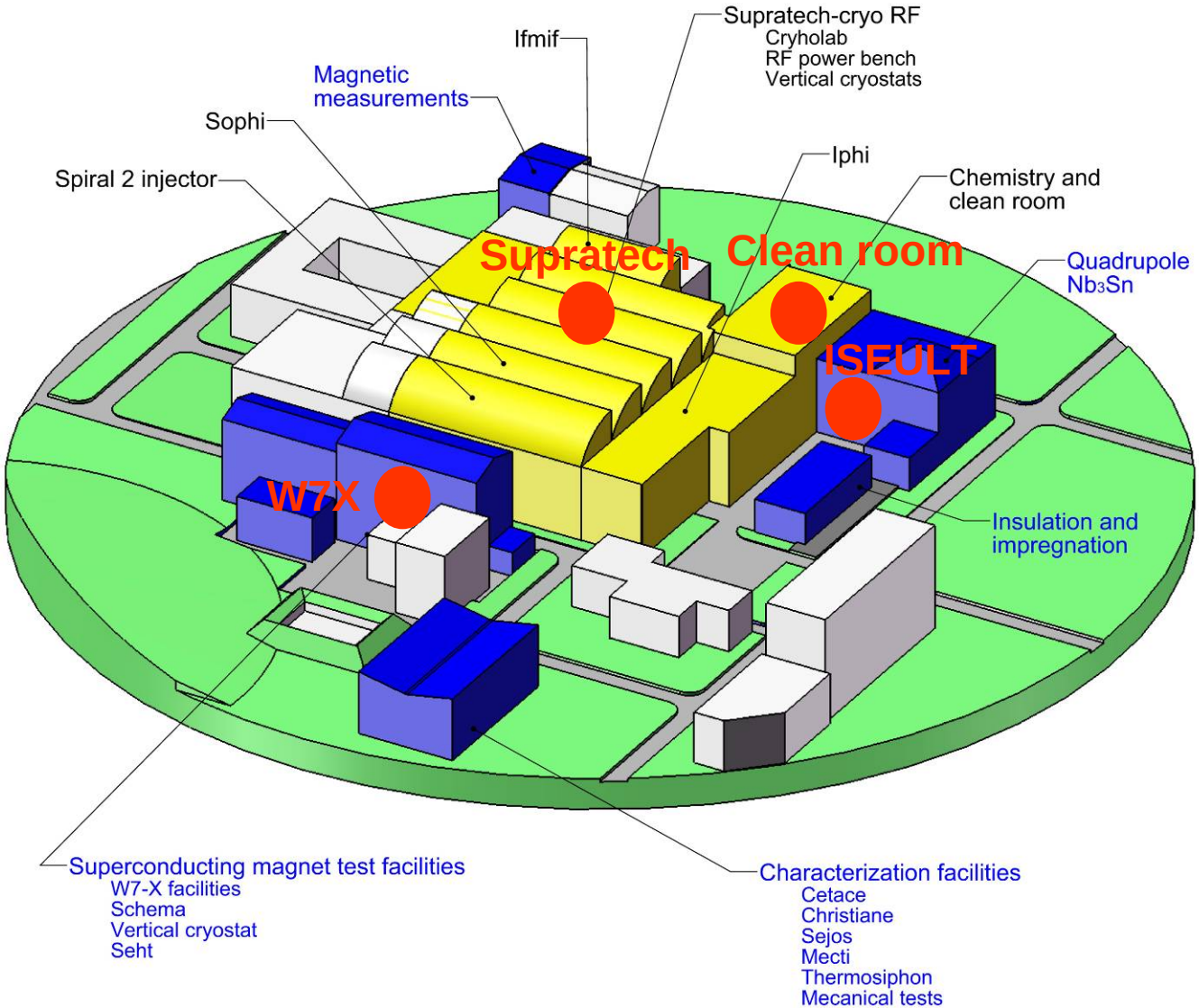
© Accel Instrument GmbH



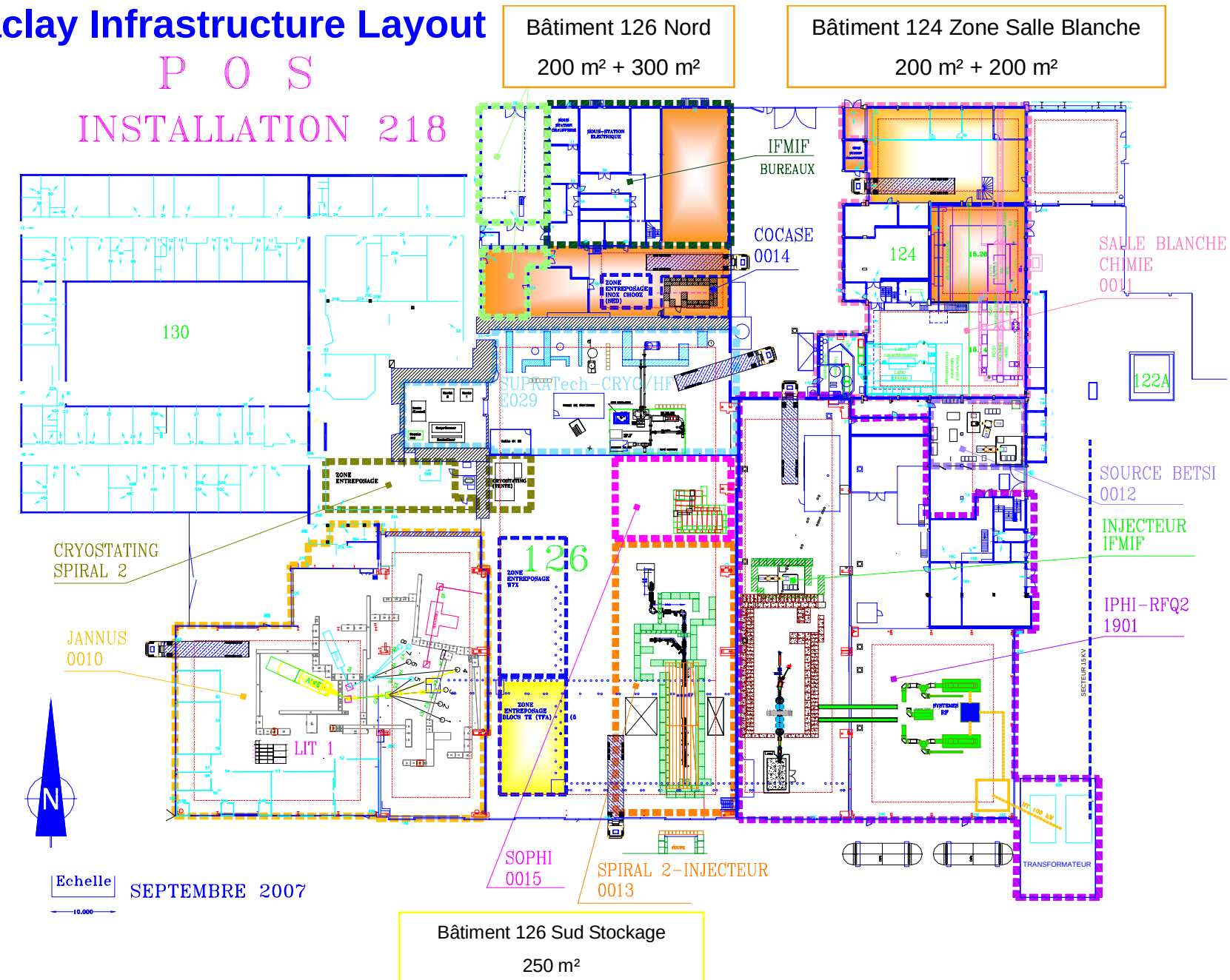


In case of technical problems, the module can be parked on redundant place.
working on other modules continues without interference

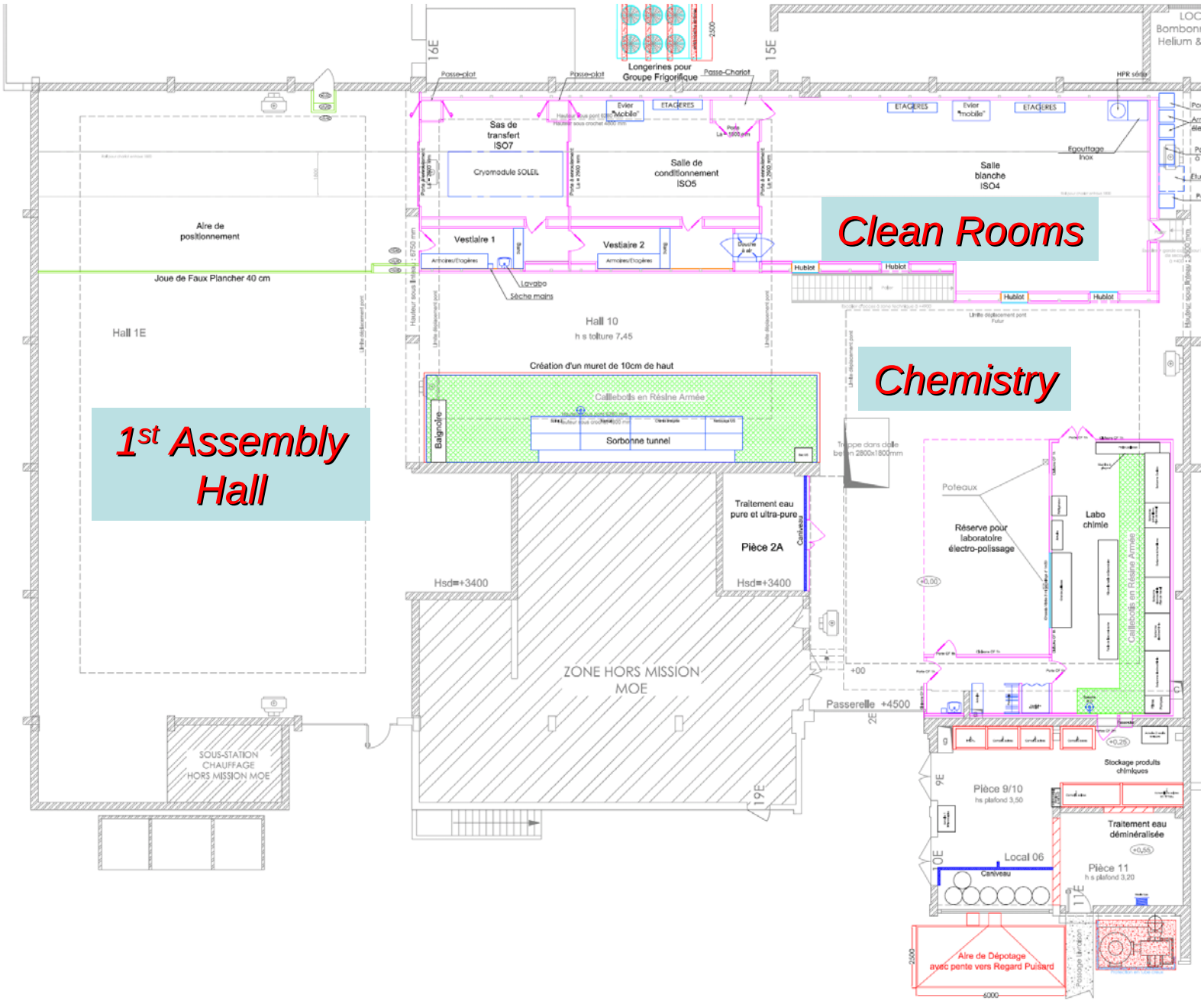
SYNERGIUM: Accelerator and Cryomagnetism



Saclay Infrastructure Layout

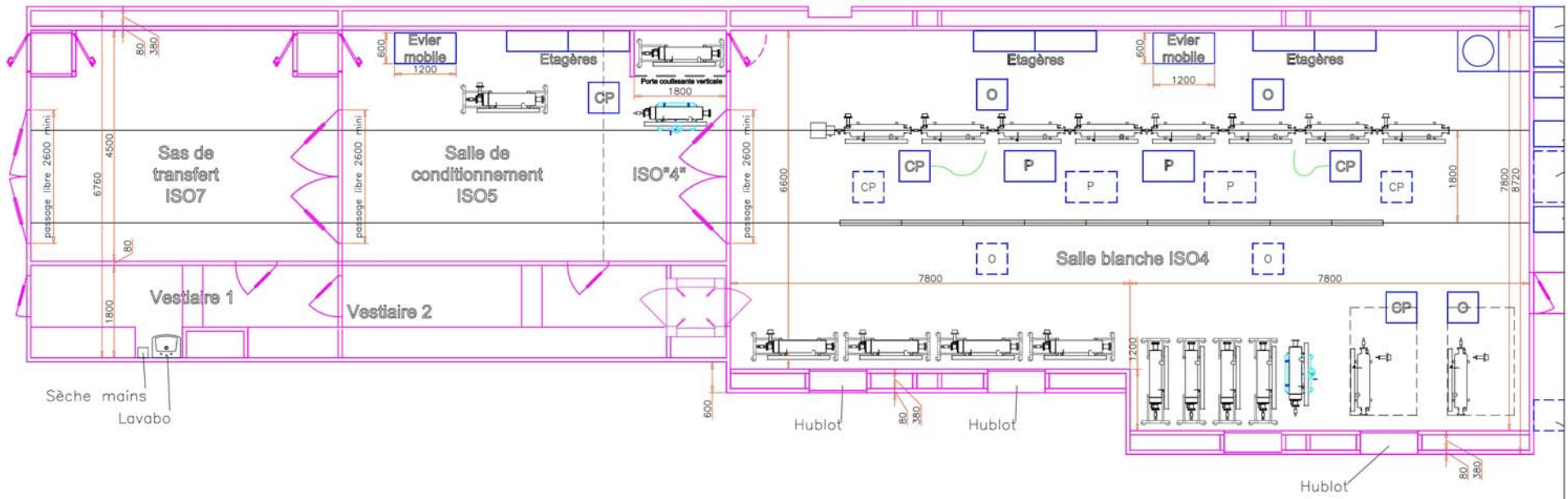


New Cavity Preparation Area



XFEL Clean Room

Design finished.
Installation June 2008.
In operation beginning 2009.



Cryomodule Industrialization

Saclay will host the Production of the 101 Cryomodules, in collaboration with INFN and DESY.

The Production will be organized in three Work Packages

1. Fabrication of Cold Masses
2. Clean Room Assembly of Cavity Strings
3. Cryomodule Assembly

All three Work Packages will be subcontracted to Industries:

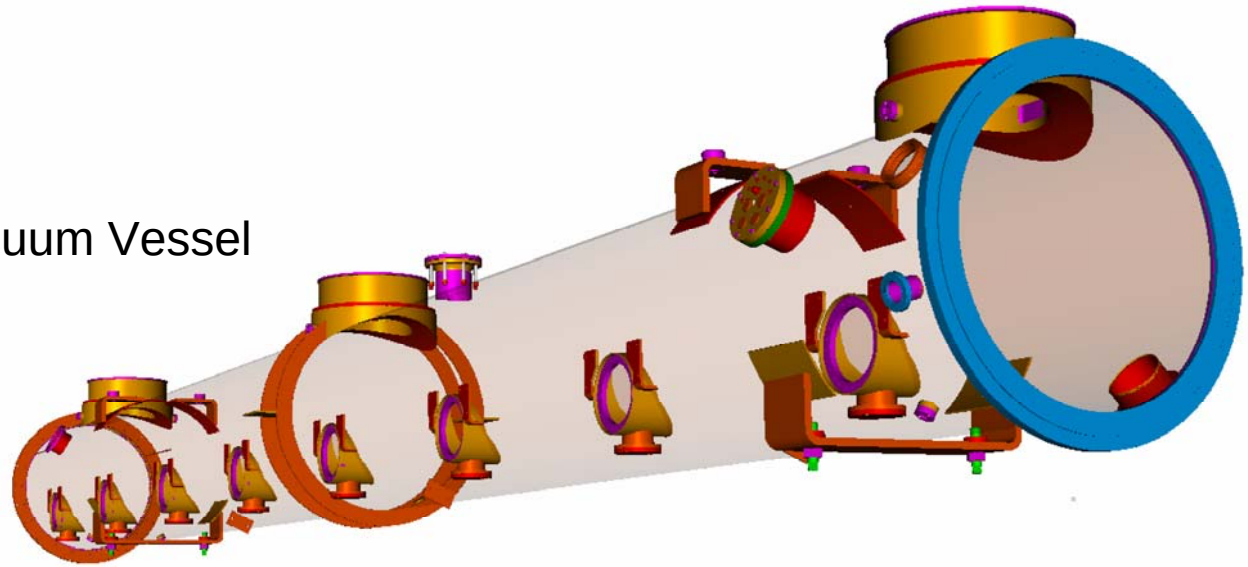
The Call for Tender Model is under discussion by the Cold Linac Consortium:

- One global vs. Three separate calls ?
- One vs. Two Industries for Cold Masses ?
- General problem of definition of the limits of responsabilities ?

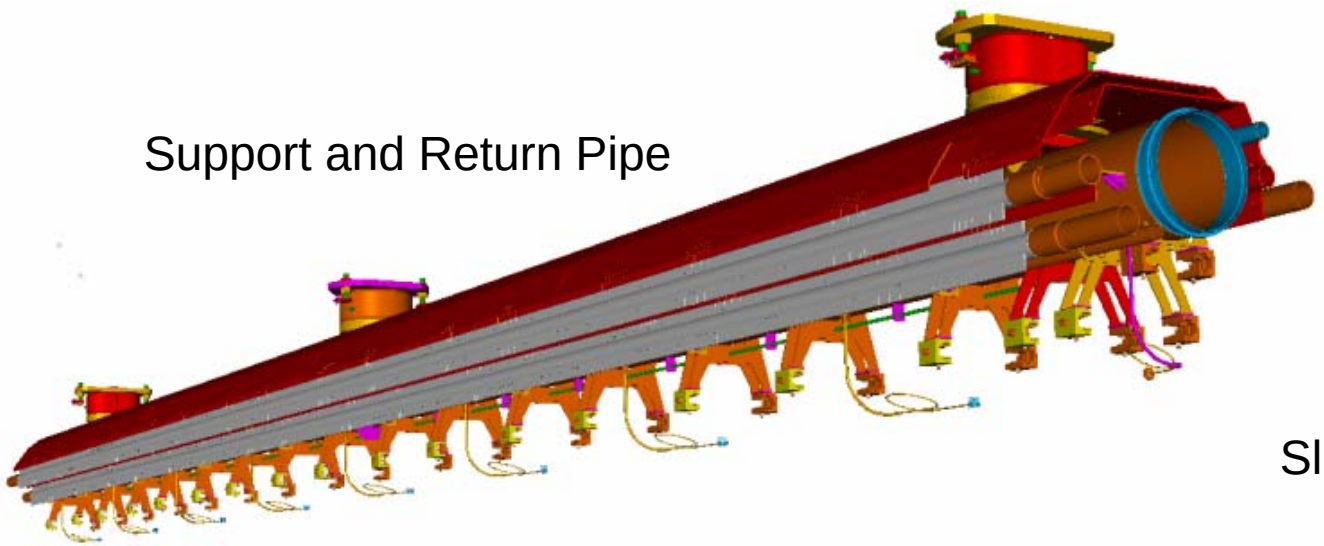
The Industrial Solution retained will set the standard for future projects

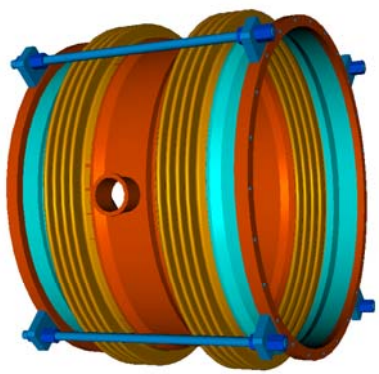
Cryomodule Cold Mass (DESY definition)

Vacuum Vessel



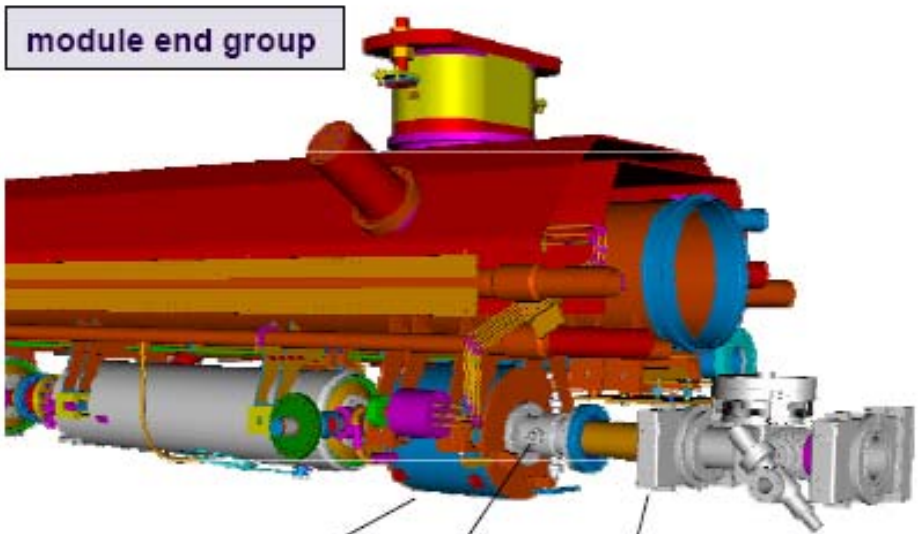
Support and Return Pipe

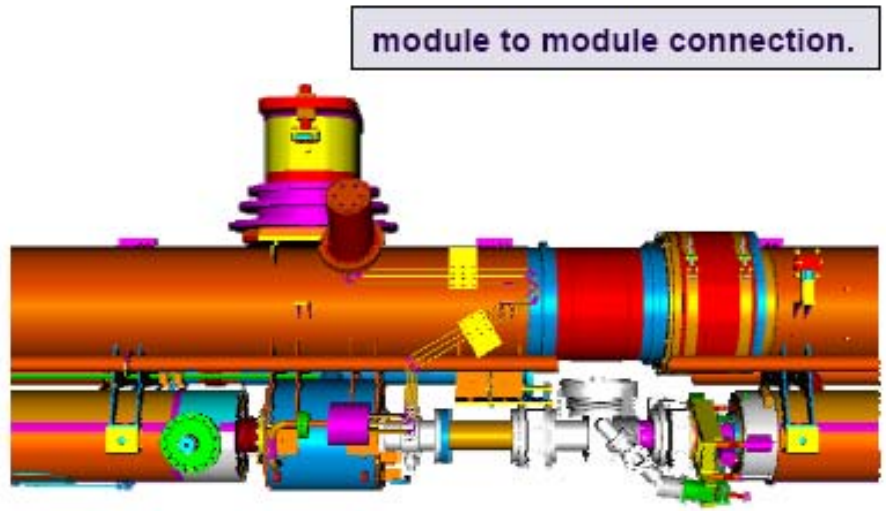


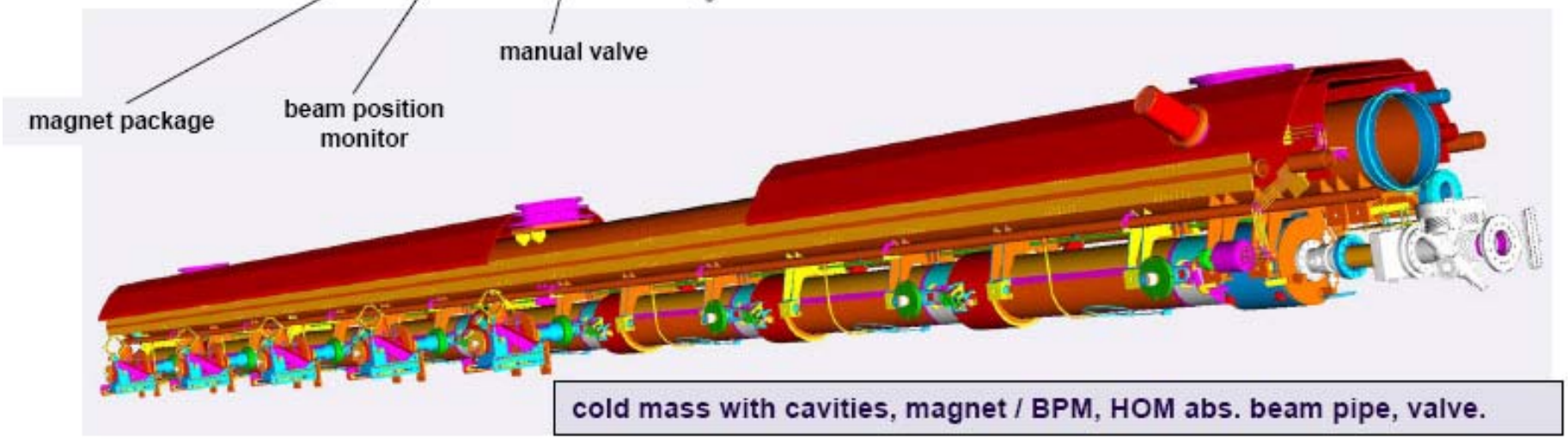


Sliding Sleeve

Cryomodule Cold Mass with Cavities



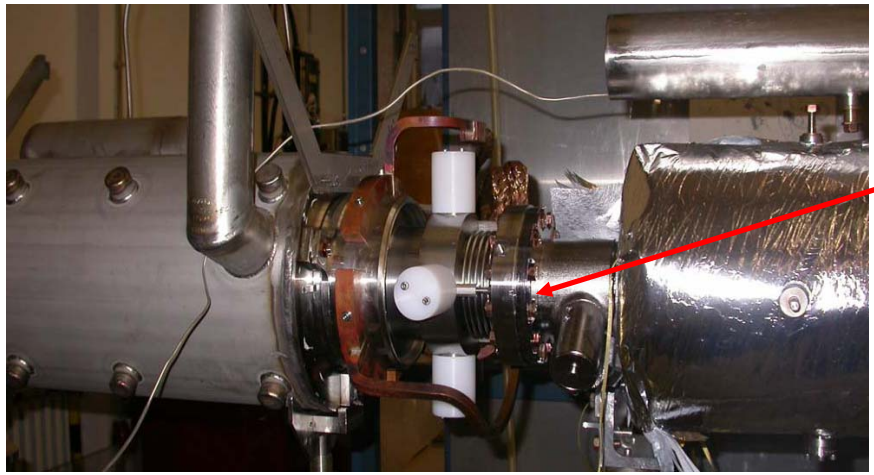




The Cold BPM

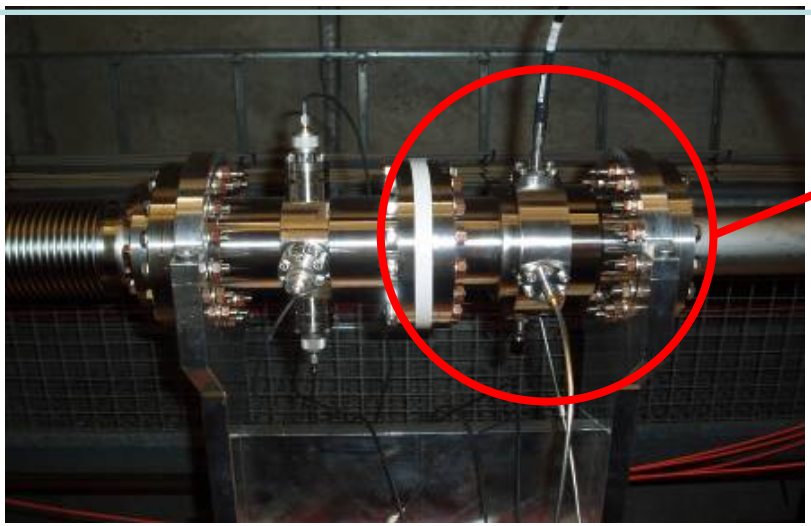
by CEA-Saclay

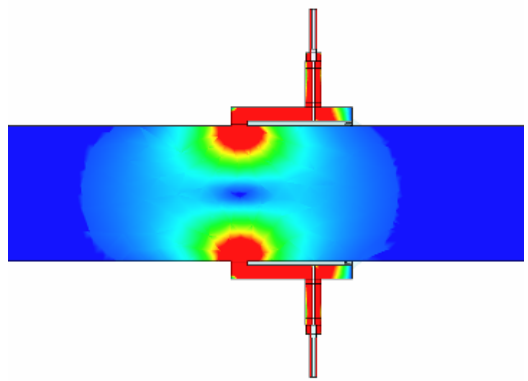
Re-entrant Cavity BPM



Re-entrant cavity BPM located at cryogenic temperature inside the cryomodule (ACC1).

Re-entrant cavity BPM installed in a warm section on the FLASH linac



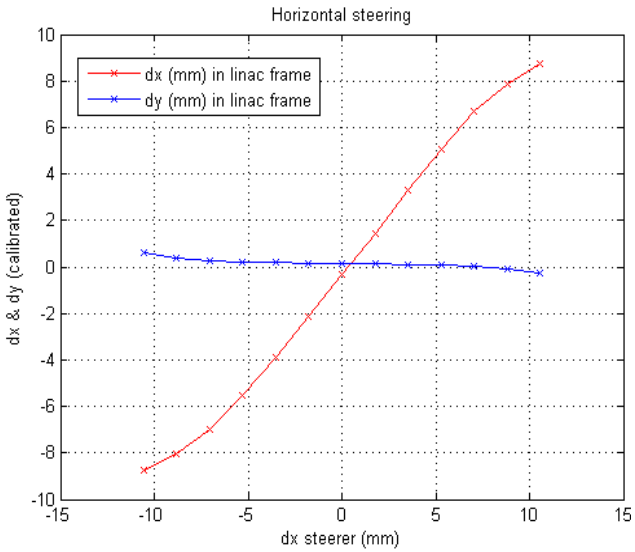


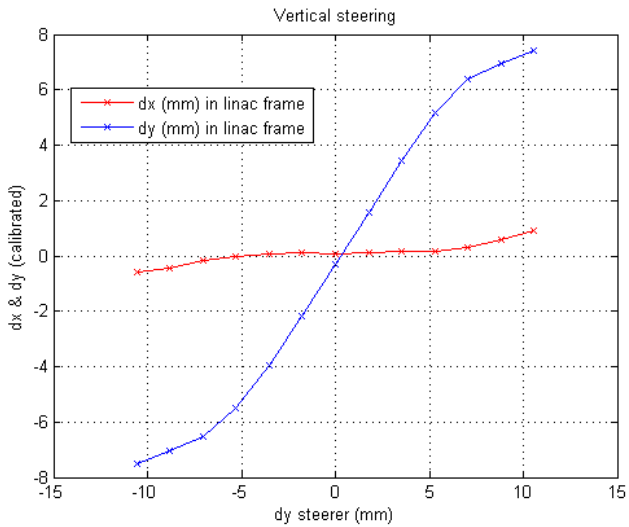
Beam Calibration at FLASH BPM-ACC7

Beam is moved with one steerer.

Calculate for each steerer setting, the relative beam position in using a transfer matrix between steerer and BPM (magnets switched off to reduce errors and simplify calculation).

Average of 500 points for each steerer setting.



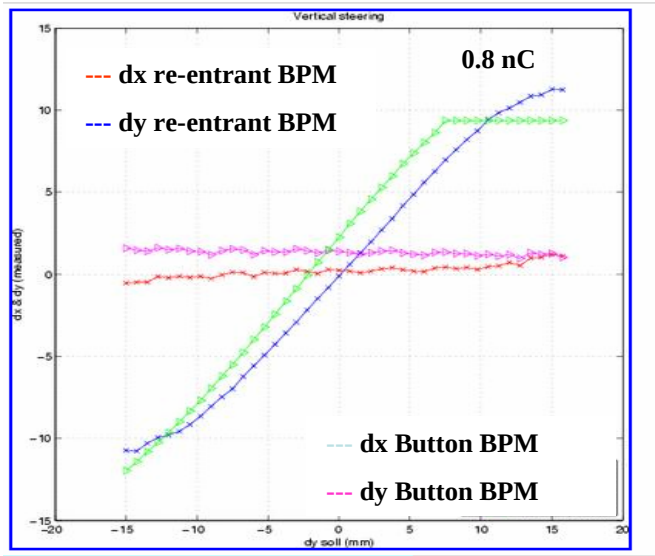


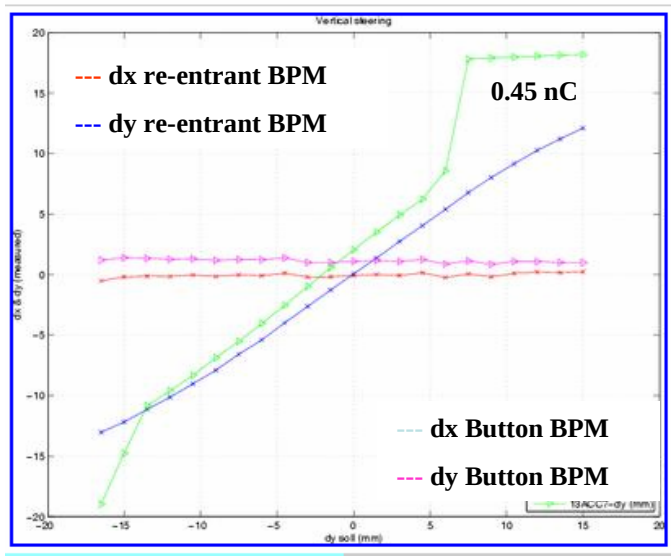
Calibration results from horizontal (left) and vertical (right) steering

Good linearity in a range ± 5 mm

RMS resolution: ~4 µm on the Y channel
~8 µm on the X channel
} **with 1 nC**

Broader dynamic range with a 6 dB attenuator on each channel





Good linearity : ± 10 mm @ 0.8 nC

± 15 mm @ 0.45 nC

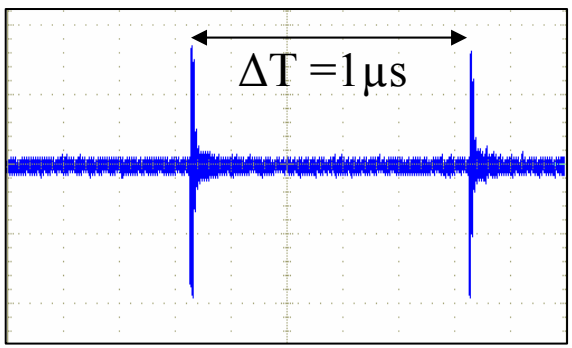
Resolution measurement:

correlation of the reading of one BPM in one plane against the readings of all other BPMs in the same plane (using linear regression).

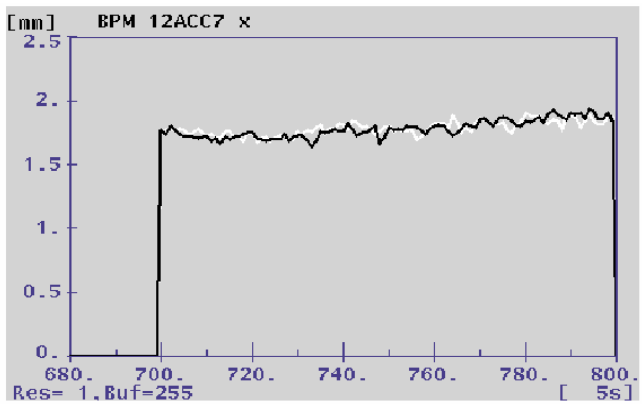
Charge	Resolution Re-entrant	Resolution Re-entrant+ 6 dB attenuator
1.0 nC	~ 4 µm	
0.8 nC		~ 12 µm
0.5 nC	~ 11.8 µm	~ 21 µm
0.2 nC	~ 30.1 µm	~ 55 µm

Time Resolution at FLASH

	Damping Time cavity only	Time resolution cavity + electronics
BPM	9.4 ns	40 ns



RF signal measured at one pickup



100 bunches read by the re-entrant BPM

Possibility of bunch to bunch measurements

BPM Summary

High resolution re-entrant cavity BPM features:

- **Effective in clean environment**
- **Operation at room and cryogenic temperature**
- **Large aperture of the beam pipe (78 mm)**
- **Position resolution around 4 μm measured with a measurement dynamic range around ± 5 mm**
- **Time resolution around 40 ns**
- **~ 20 to 30 BPMs will be installed in the XFEL Linac.**

This BPM is a good candidate for being installed in the ILC cryomodules