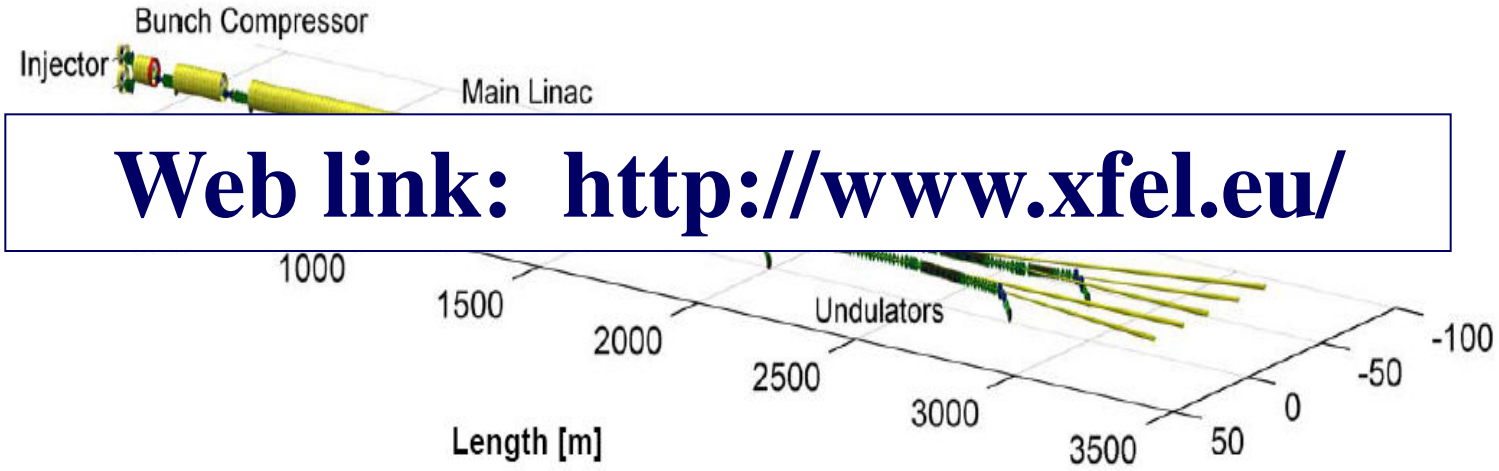
XFEL: cryomodule assembly at CEA/Saclay

- ***XFEL facility & Superconducting linac***
- ***Main assembly steps***
- ***Industrial operation at Saclay***
- ***Preparation of the infrastructure***
- ***Plans and Schedule***

European-XFEL

The European XFEL is a new research facility currently under construction in the Hamburg area in Germany.
From 2014 on, it will generate extremely intense and ultra short X-ray flashes.

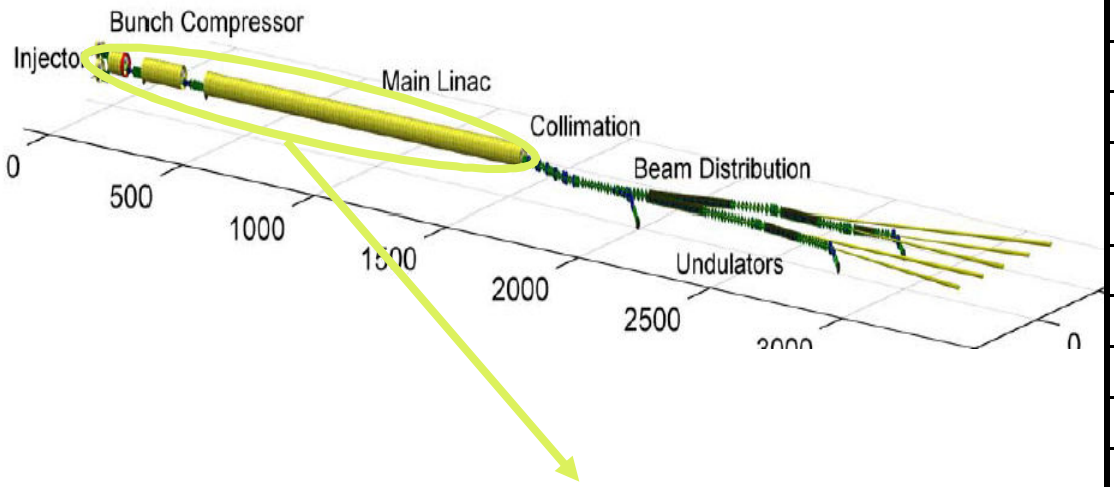


Web link: http://www.xfel.eu/

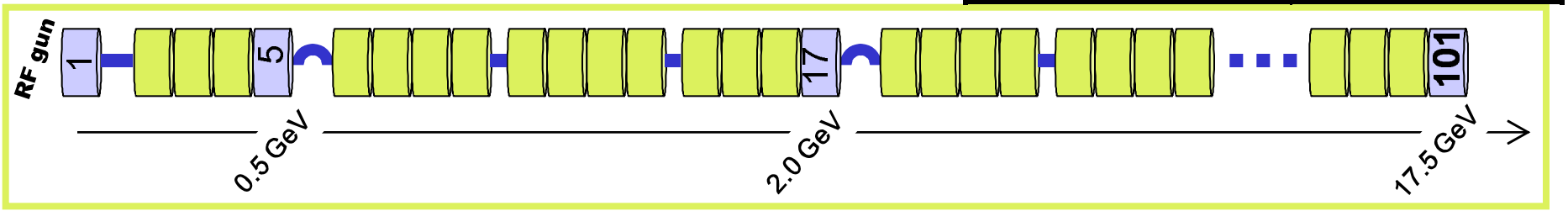
Frequency of flashes	30 000 per second
Wavelength	0.1 to 6 nm
Flash duration	< 100 fs
Brillance (peak value)	$5 \cdot 10^{33}$ (photons / s / mm^2 / mrad^2 / 0,1% bandwidth)
Brillance (aver. value)	$1.6\ 10^{25}$ (photons / s / mm^2 / mrad^2 / 0,1% bandwidth)

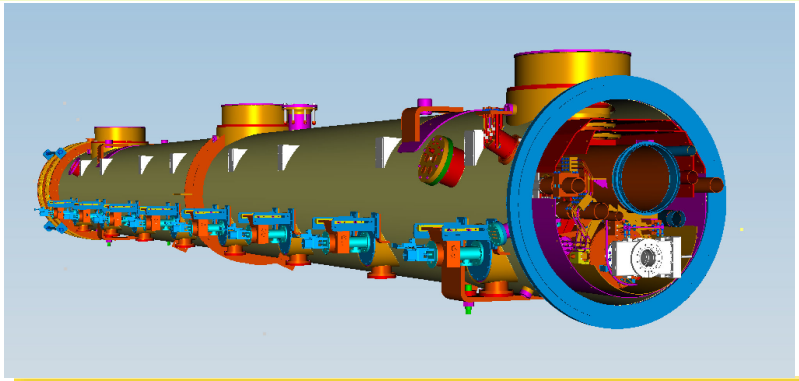
- On 8 January 2009, civil engineering work (tunnels, shafts, halls) has been started at all three construction sites
- International state convention for the foundation of the European XFEL GmbH on 23 September 2009 in Berlin initialled by the representatives from the currently 13 partner states
- Official registration of the 'European X-Ray Free-Electron Laser Facility GmbH', into the Commercial Register of the Hamburg District Court on 08 October 2009

XFEL: the Superconducting linac



Linac and cavity parameters	
Energy	17.5 GeV
I_{beam}	5 mA
f_{RF}	1300 MHz
f_{rep}	10 Hz
t_{RF}	1.4 ms
t_{beam}	0.650 ms
Total length	2.1 km
Acceleration length	1.7 km
Cavity gradient	23.6 MV/m
P_{RF} / coupler (pk, av.)	120 kW, 1.7 kW





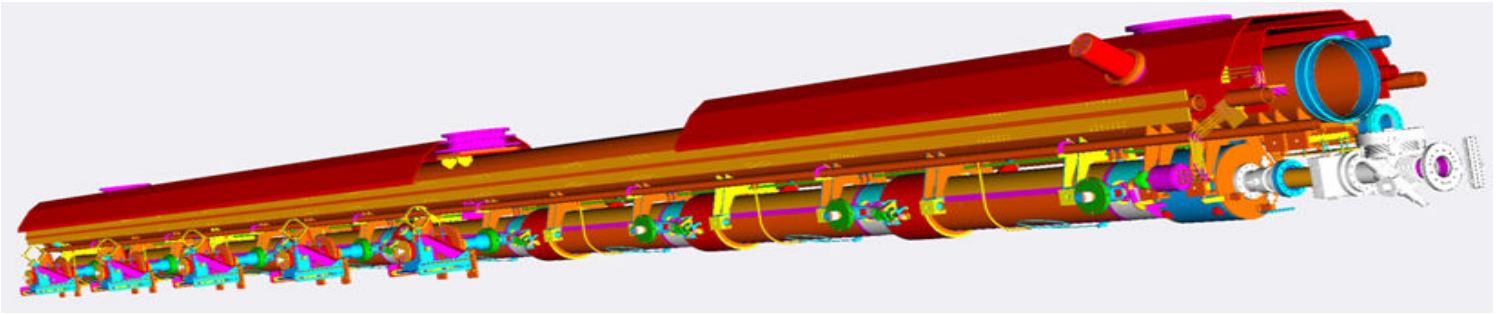
Superconducting linac

= 101 cryomodules

= 808 9-cells cavities +

808 couplers & tuners & …

XFEL: Cryomodule Assembly



- Sequences of cryomodule assembly were optimised at DESY and took benefit from assembly of several TTF and FLASH cryomodules.

- Assembly sequences qualified by:
  - Results of RF tests performed at DESY
  - Operational performance on FLASH

- These main sequences are kept unchanged for the assembly of XFEL cryomodules at Saclay

Cryomodule Assembly: main sequences (1)

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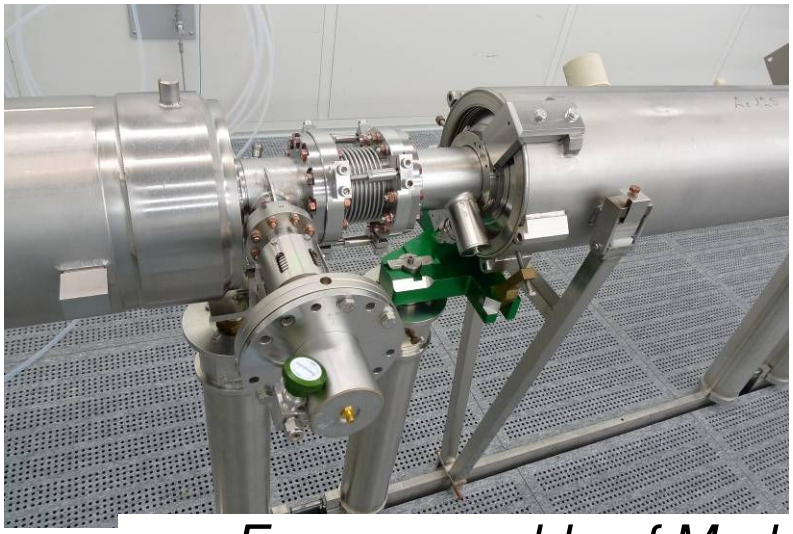
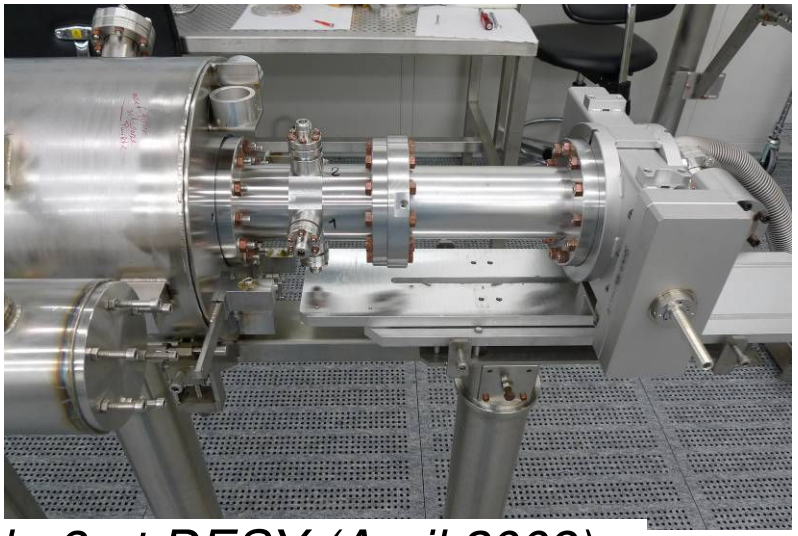
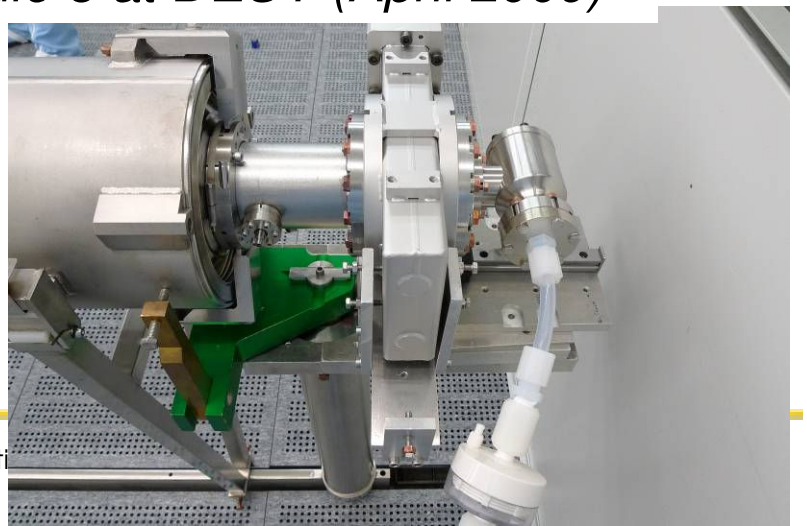
In clean room class 10 (ISO4):

Assembly of the components sealing the cavity vacuum:
Cavities, bellows, cold part of the couplers, end-group, valves





From assembly of Module 8 at DESY (April 2009)



Cryomodule Assembly: main sequences (1bis)

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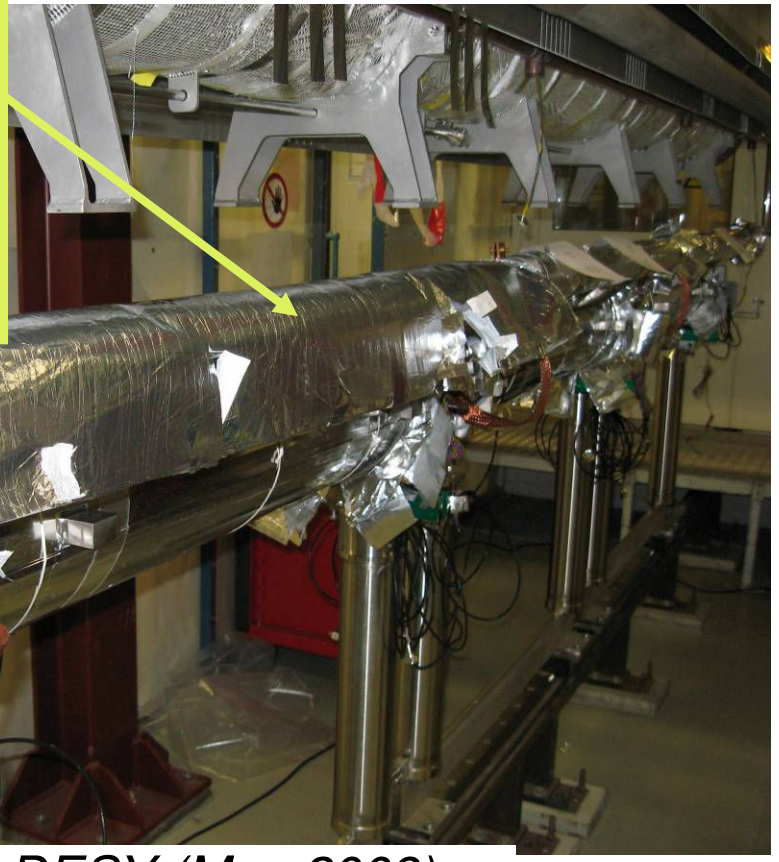
Cavity string = - vacuum valve
- 8 cavities (in their LHe tank) with bellows
- end group = Qpole + BPM
- HOM tube
- vacuum valve

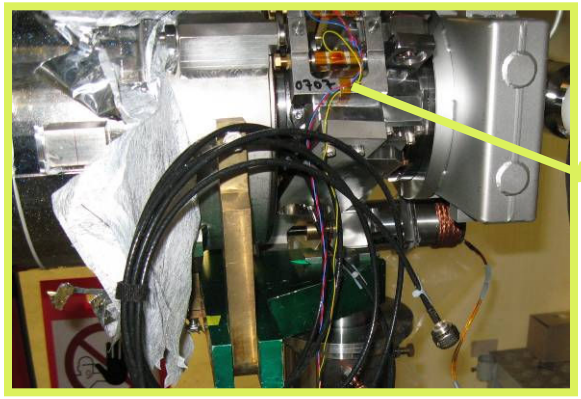
End of cavity string assembly in DESY clean room

Cryomodule Assembly: main sequences (2)

Outside the clean room (on the same rail):

Assembly of components fixed to the cavity (Helium tube, magnetic shielding, SI, tuners, …)



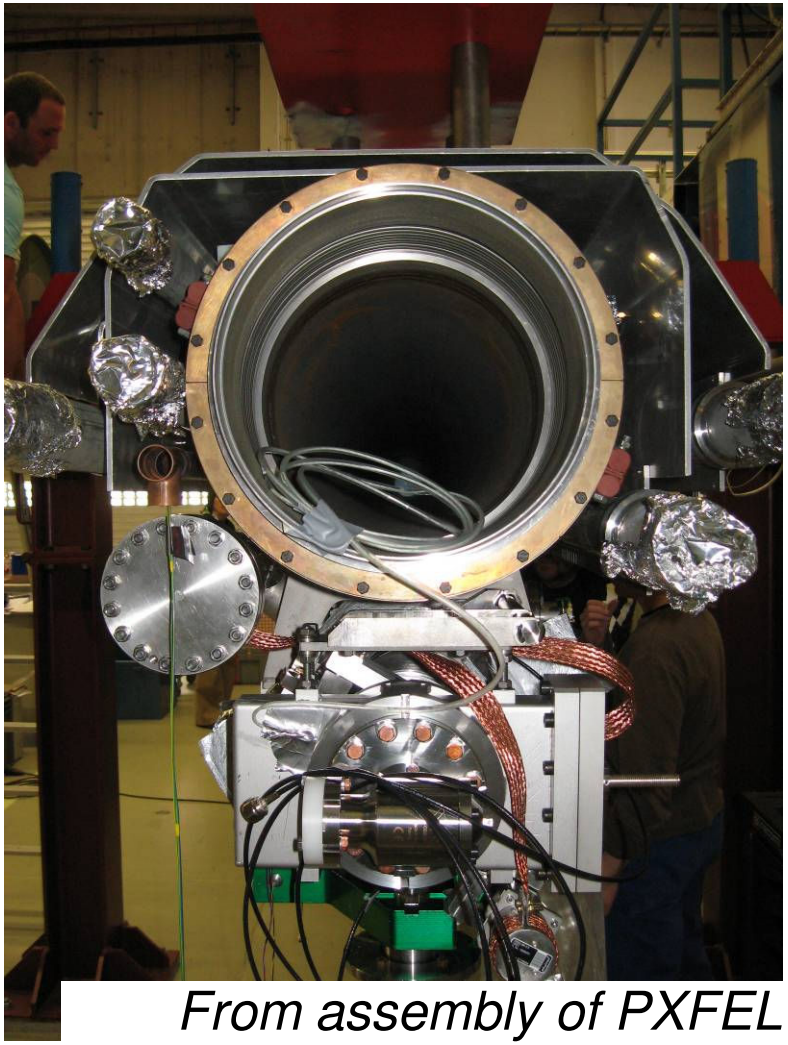


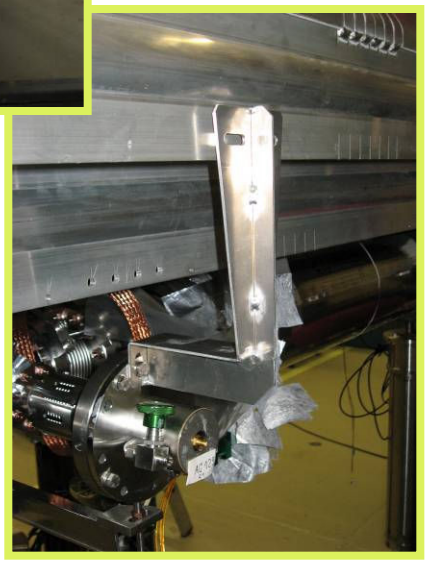
From assembly of PXFEL1 at DESY (May 2009)

Cryomodule Assembly: main sequences (2bis)

Outside the clean room (on the same rail):

Connection to cold mass





From assembly of PXFEL1 at DESY (May 2009)

Cryomodule Assembly: main sequences (2ter)

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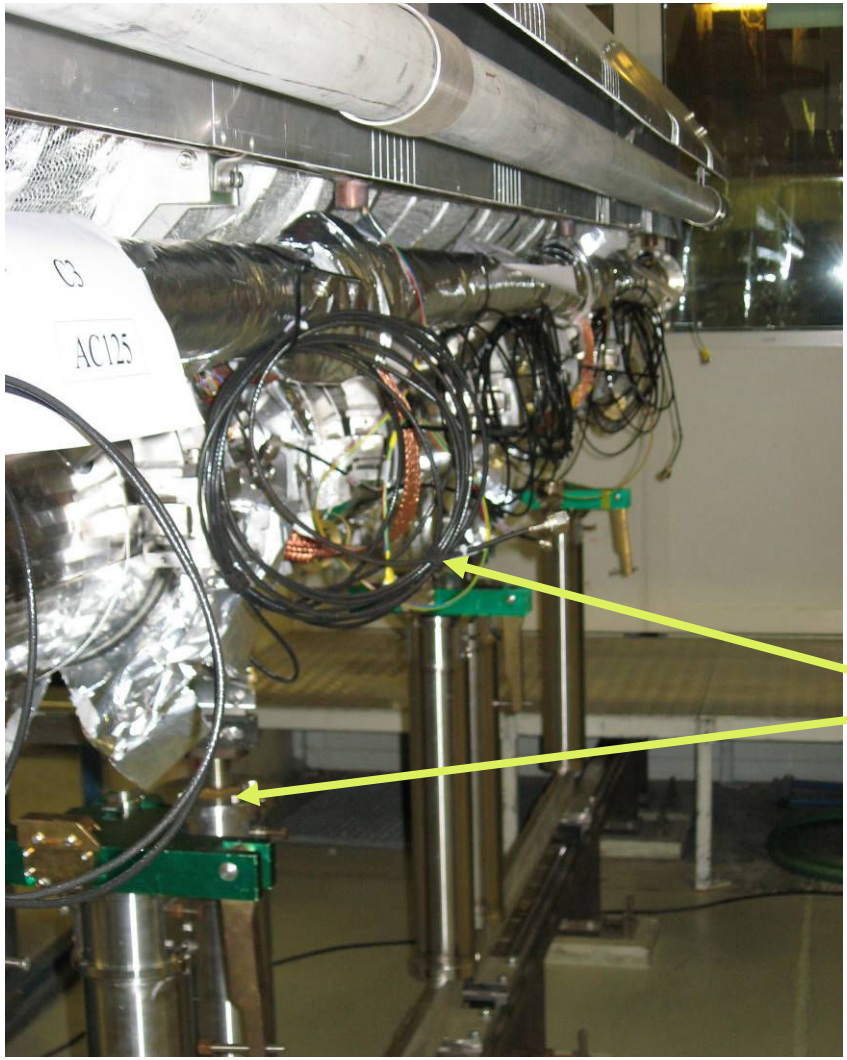
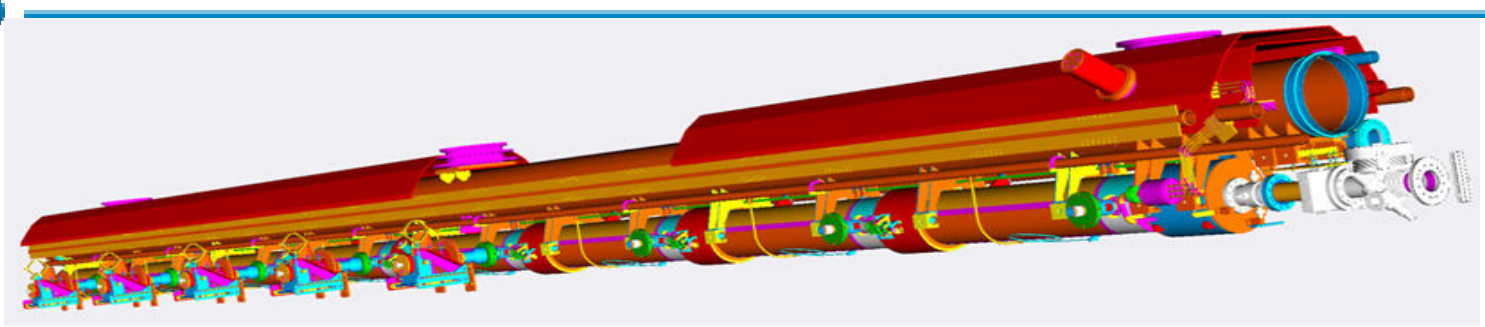


- Assembly of the cold part (cavity string + cold mass) of the cryomodule almost completed at this stage.
- Cavity string disconnected from the support posts

From assembly of PXFEL1 at DESY (May 2009)

Cryomodule Assembly: main sequences (3)



- The whole part can be moved with a crane to an **area equipped for alignment** of the cavities + end-group (tol.<500μm)

- Further assembly (thermal shields and braids, cabling, welding, SI,…)

- Assembly of the cold part is now completed and ready to be moved into the vacuum vessel with the **cantilever**

Cryomodule at DESY

Cryomodule Assembly: final sequences

After assembly of the warm part of the couplers & the last connections, the cryomodule is ready for shipment

Cryomodule 8 with caps and frame at Saclay before transport to DESY

Assembly: Industrial operation at Saclay

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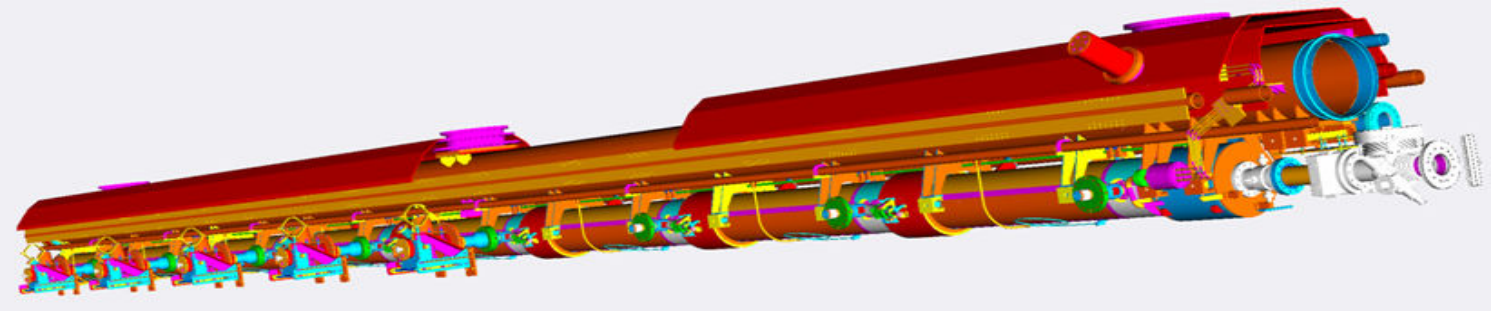

CEA committed to supervise
the assembly of 3 pre-series and 100 series XFEL cryomodules
at Saclay

Cost book 2005	WP3a Cold Mass Fabrication		WP3b Module Assembly & Installation		WP5 Coupleurs RF		WP9 Assemblage Trains de Cavités	
	M&S	FTE	M&S	FTE	M&S	FTE	M&S	FTE
DESY	25%	51%	4%	61%	20%	20%	3%	44%
INFN	25%	16%	-	-	-	-	-	-
CEA	50%	33%	96%	39%	-	-	97%	56%
IN2P3	-	-	-	-	80%	80%	-	-

Assembly: Industrial operation at Saclay

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The main requirements:

- Assembly of cavity string in clean room ISO 4
- Production throughput of 1 CryoModule / week

Preparation of the industrial operation at Saclay:

- Industrial pre-study (2008)
- Study and order of the 'big' tools (2009-2010)
- Complementary industrial study "EPPS" (starts in January 2010)

Assembly: Industrial Operation at Saclay

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Industrial pre-study in 2008 (Thalès): defining the infrastructure and establishing the fabrication folder

- identification of the Work Stations
- definition of equipments and tools
- storage of big CryoMod parts and warehouse
- composition of the working teams
- preliminary schedule over one week
- preliminary risk analysis (back up WS, redundancy)

Main outcome: the drawings of the clean room were modified in order to meet the requirements of the Op.

- a second rail be implemented in CR
- a dedicated area for assembly of coupler with cavity is created
- components are introduced into CR through a cavity washer (ISO4)

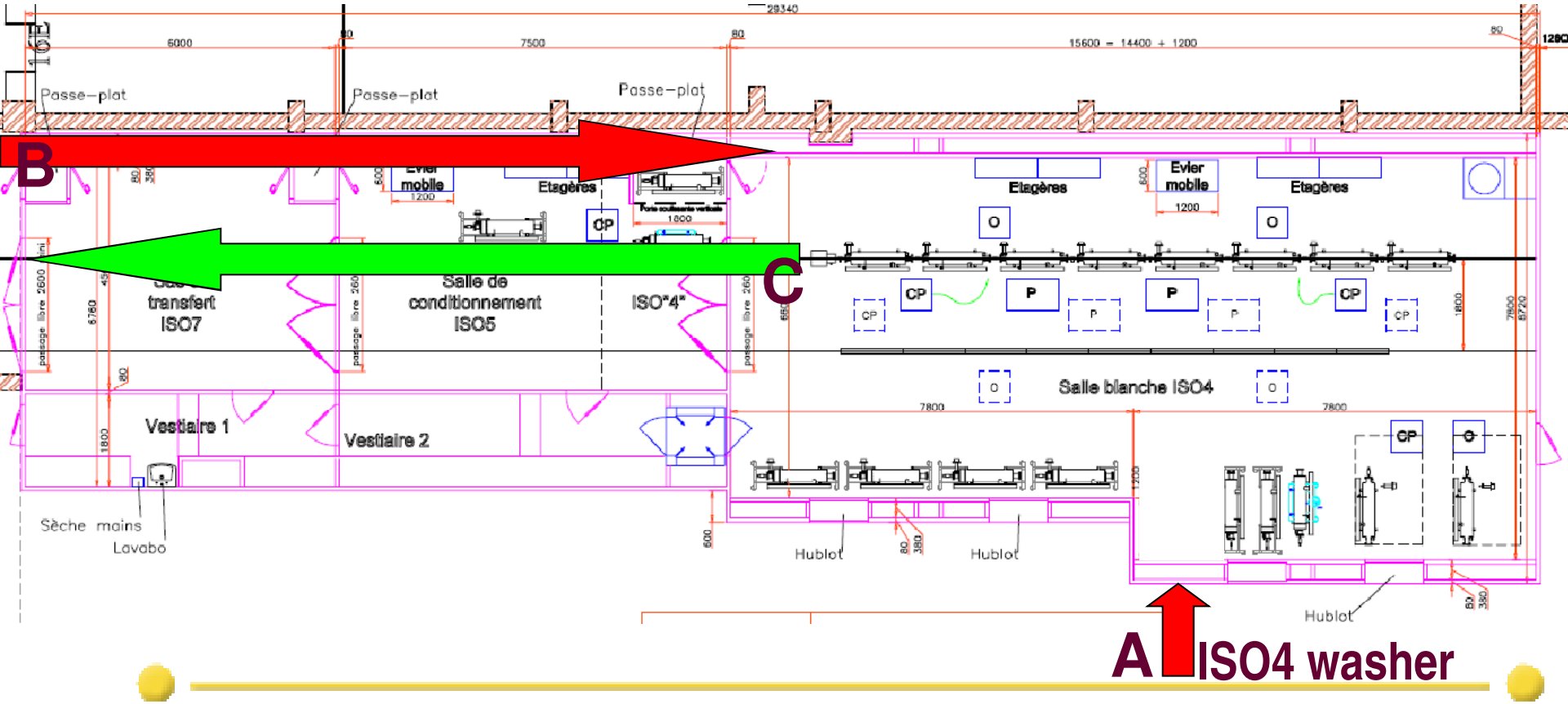
Clean room: work flow

Inventory of pieces entering or exiting the CR each week:

A- Cavity x 8 ; Coupler cold part x 8 ; End-group

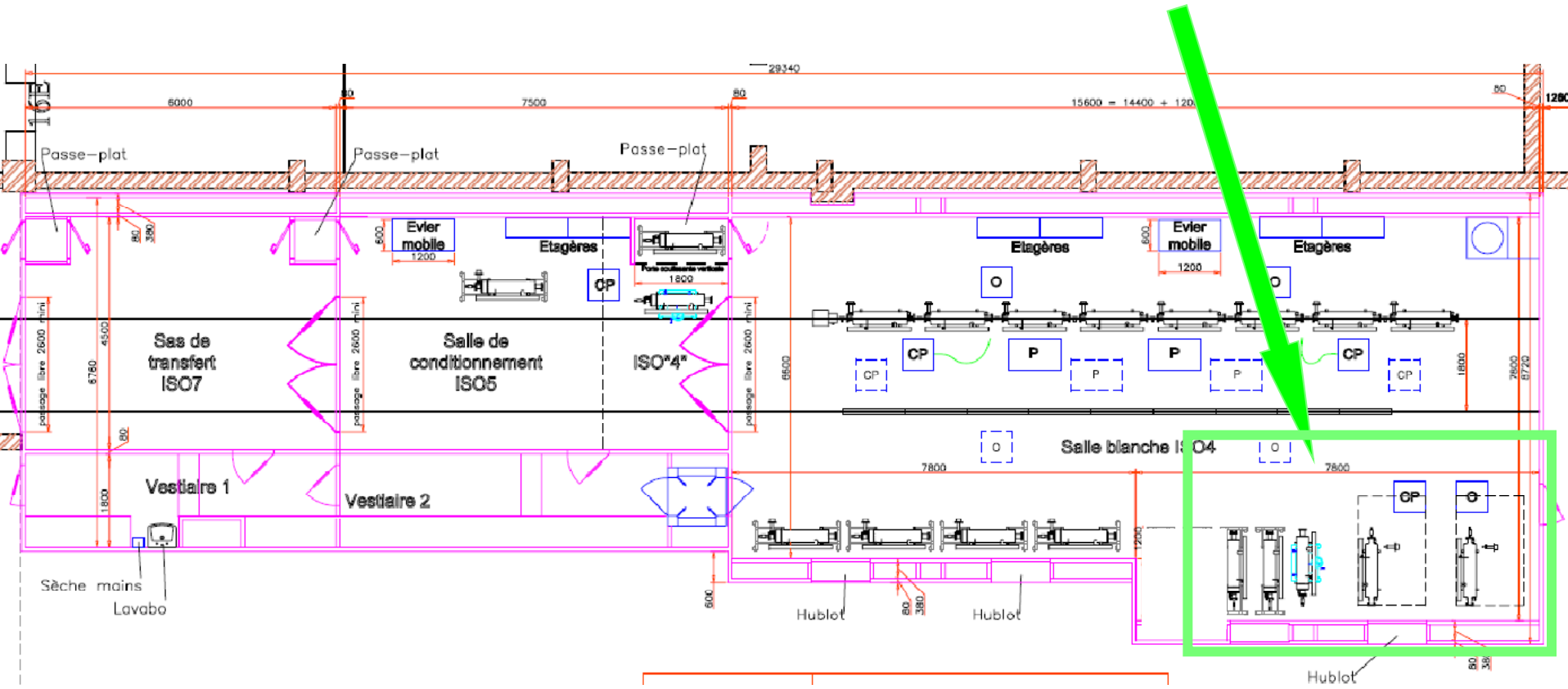
B- 200 tools (valves, posts, fixtures, …) ; 1200 pieces (bolts, nuts, gaskets, …) ; consumables (gloves, wipes, …)

C- Cavity string with posts ; broken pieces ; waste

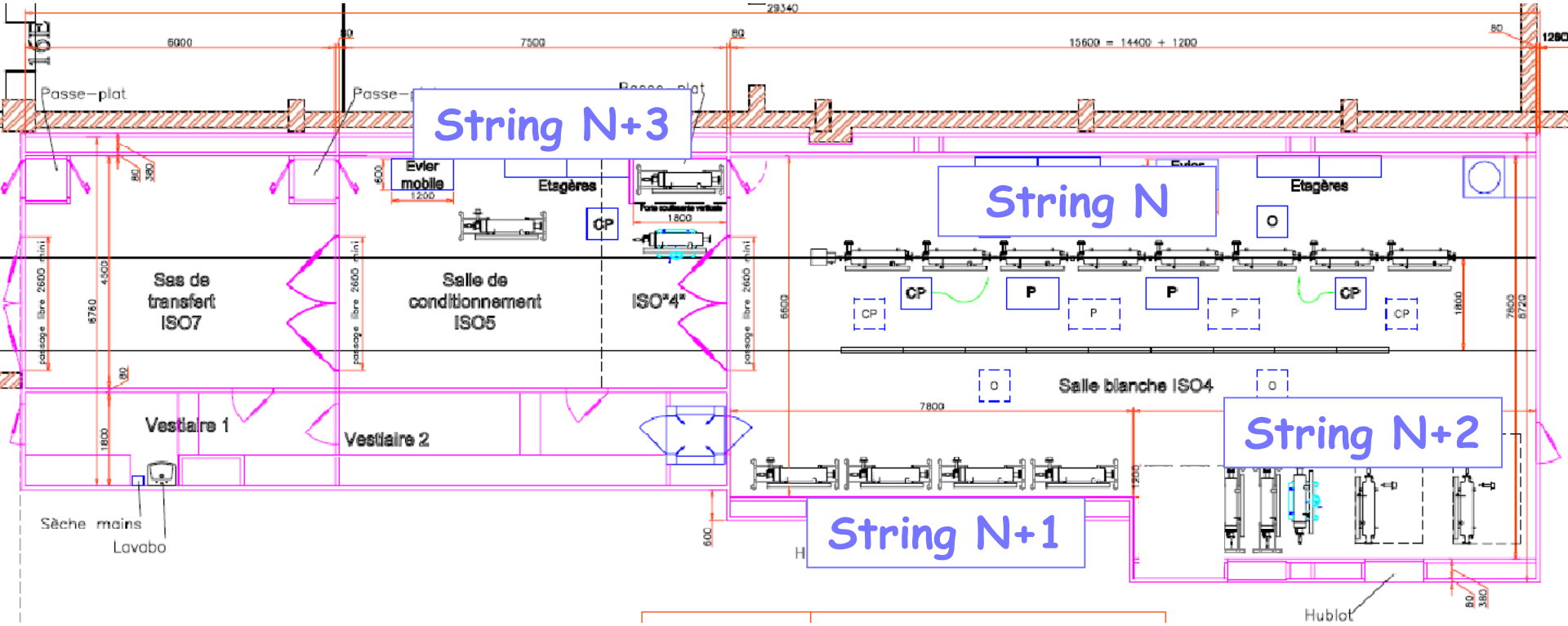


Clean room: coupler work station

As a consequence of the production throughput, a dedicated work station is added for assembly of couplers with cavities

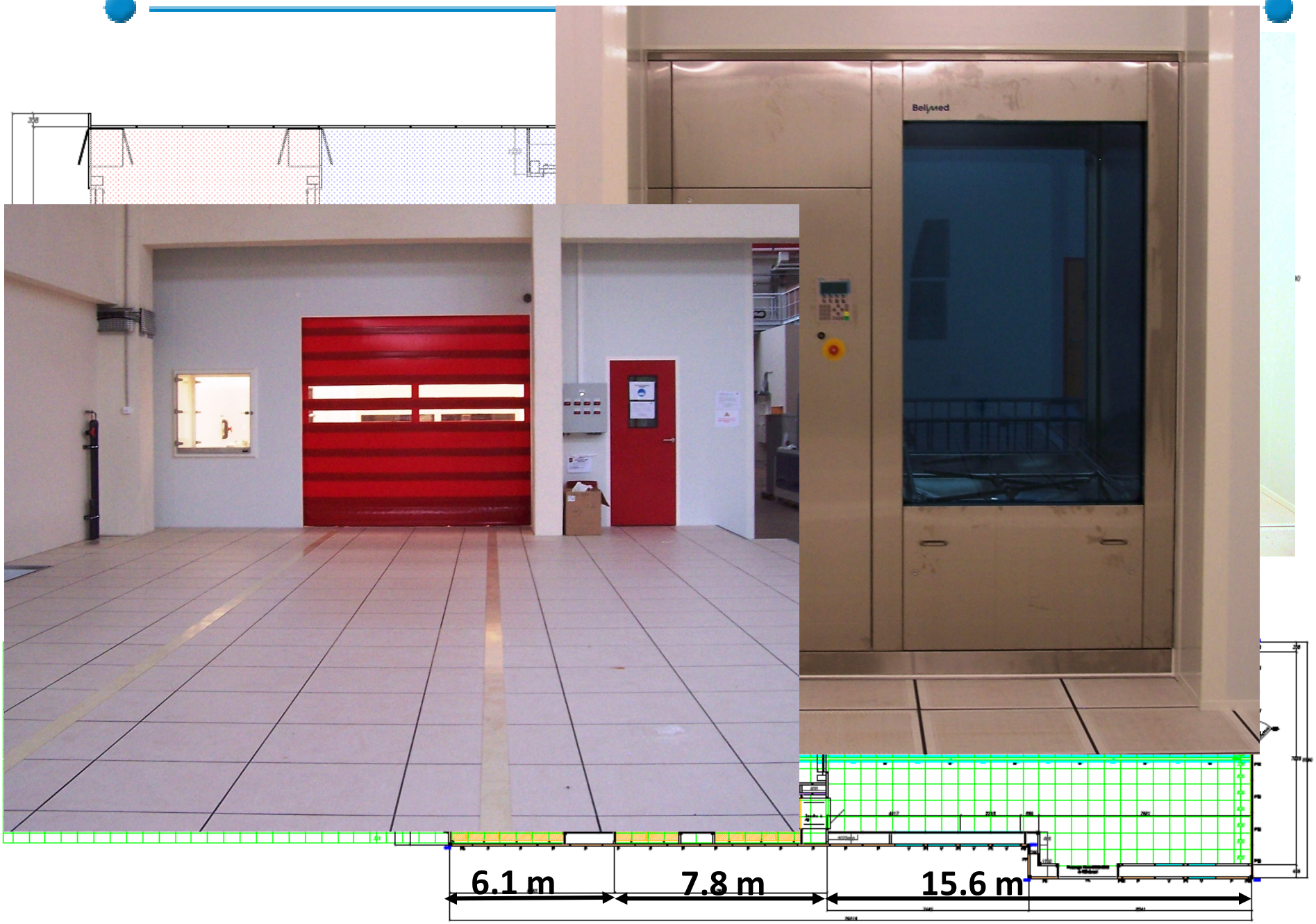


Clean room: how many work-stations in the CR ?



As a consequence of the production throughput, cavities for 4 successive strings are in the CR

Infrastucture: clean room (as built)



Assembly: Industrial Operation at Saclay

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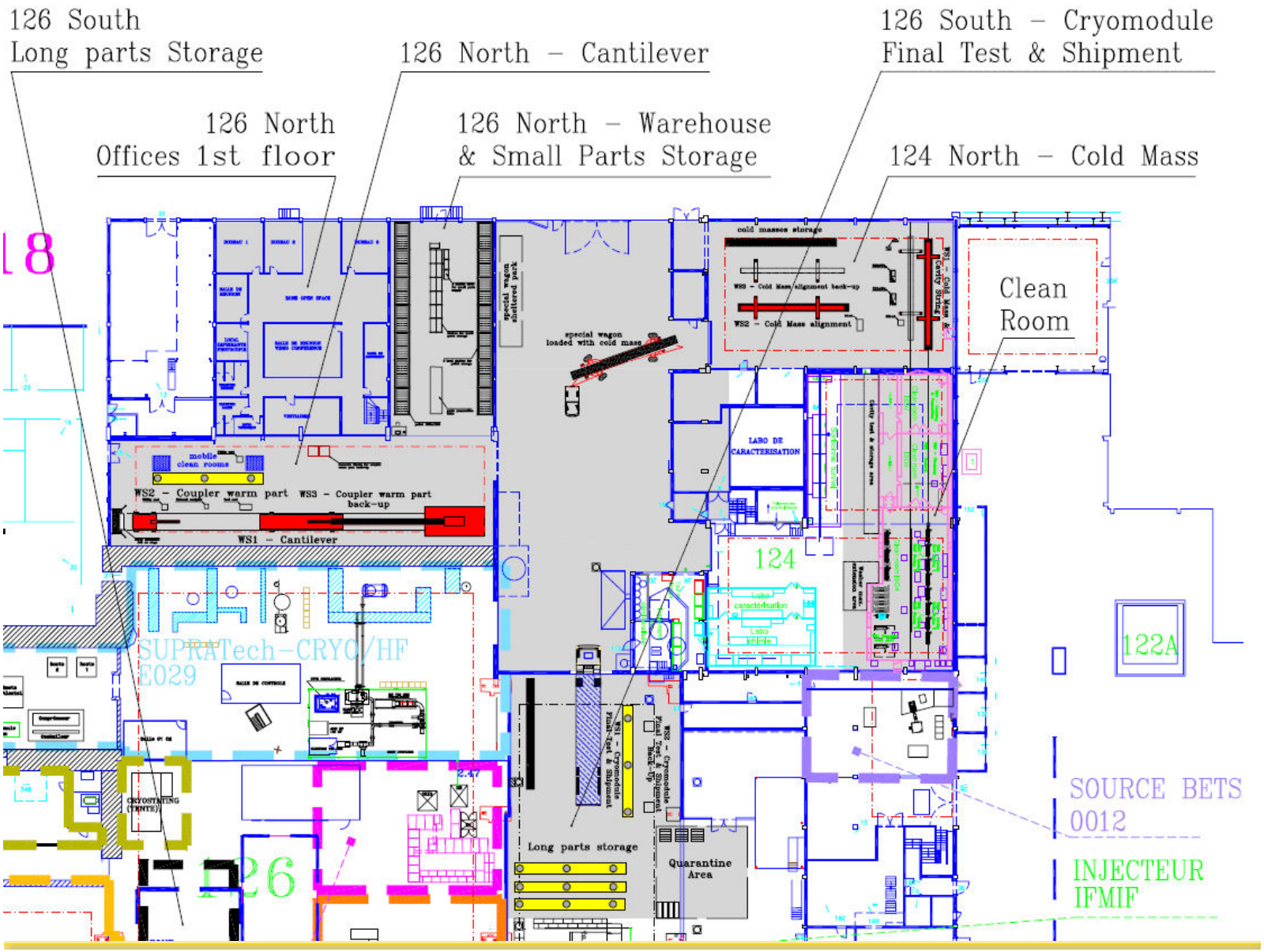
Industrial pre-study in 2008 (Thalès): defining the infrastructure and establishing the fabrication folder

- identification of the Work Stations
- definition of equipments and tools
- storage of big CryoMod parts and warehouse
- composition of the working teams
- preliminary schedule over one week
- preliminary risk analysis (back up WS, redundancy)

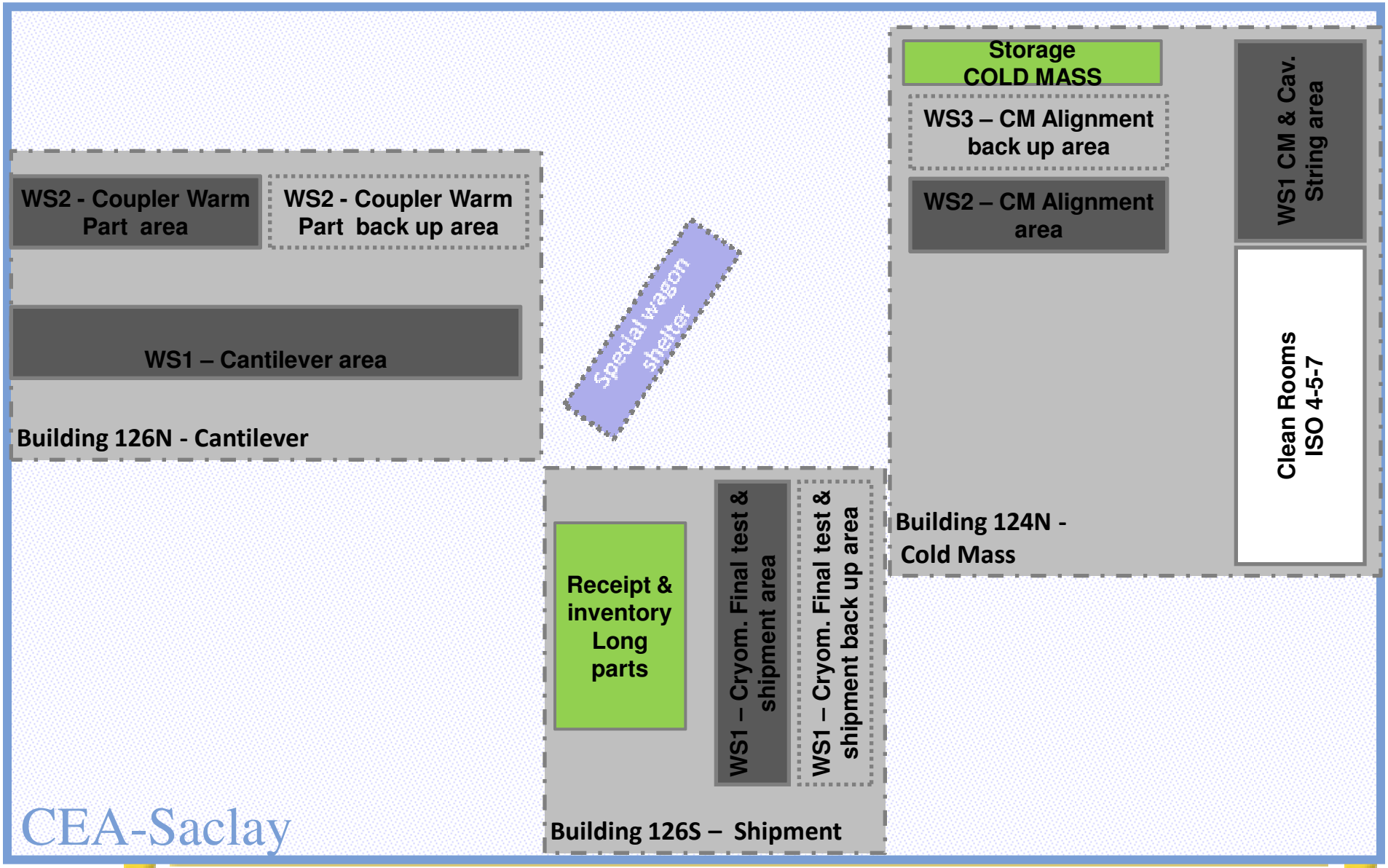
Other main outcome: selection of one configurations of work stations amongst several

- easy access to each of the workstation from the central court
- the moving of all parts from their actual WS to the next is possible within one day (working hours)
- the whole area can be delimited (XFEL Village)

Final configuration of Work Stations

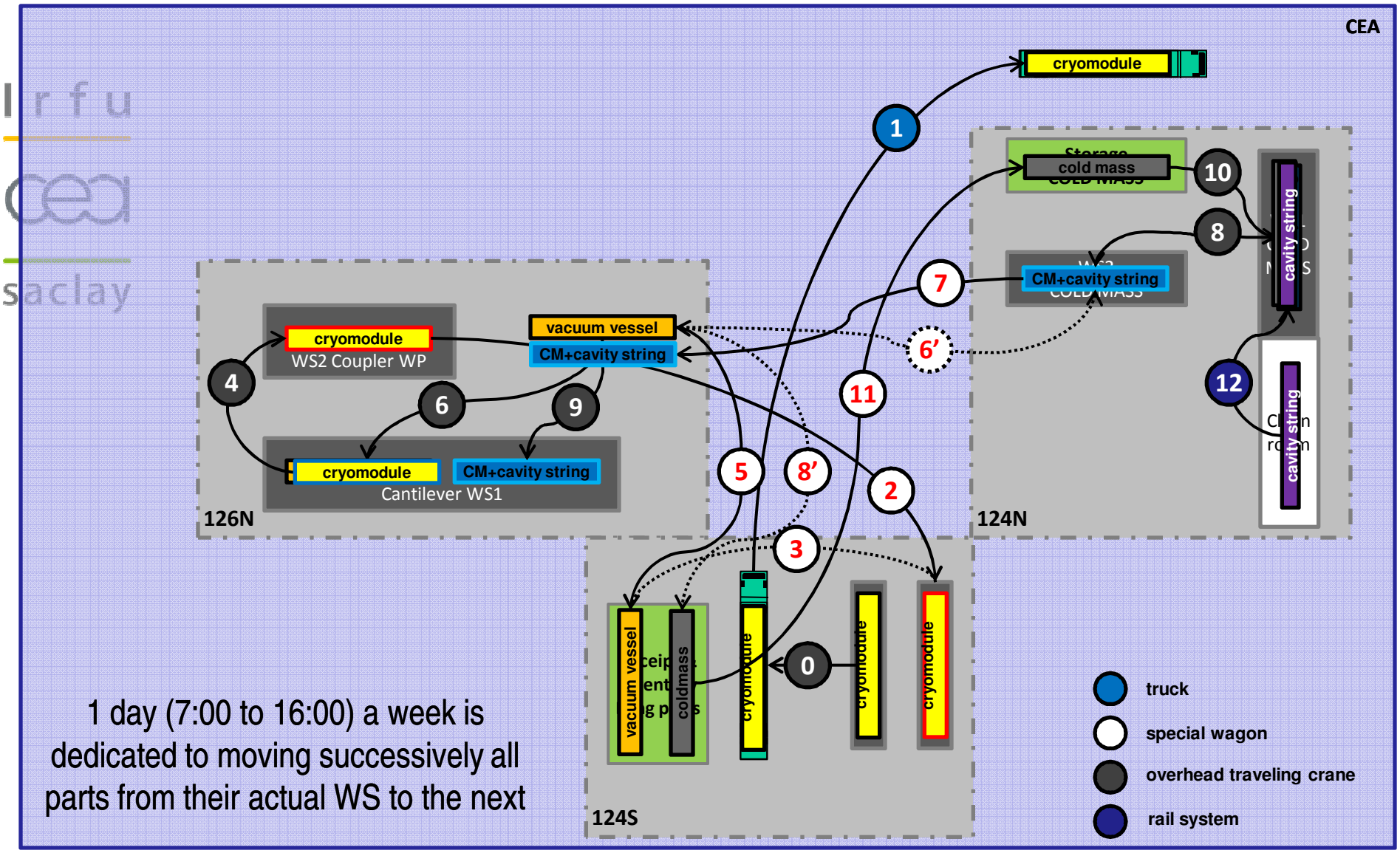


Definition of the other Work Stations



CEA-Saclay

Optimisation of long parts flow



1 day (7:00 to 16:00) a week is dedicated to moving successively all parts from their actual WS to the next

Plans and schedule

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Preparation of the infrastructure:

- Clean room available very soon (Nov. 09)
- Completion of renewing of assembly halls expected in 2 months
- Delivery of the big tools in March 2010

Preparation of the industrial Op. :

Complementary industrial study “EPPS” should start in Jan. 2010.

Industrial operation at Saclay:

- Assembly of the 3 pre-series cryomodules in 2011 (2nd sem.)
- Assembly of 100 cryomodules (ramp-up and production) from 2012 to 2014.

Concluding remarks

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All the procedures and sequences of assembly were intensively optimized at DESY this last decade

Definition of Saclay Infrastructure was strongly impacted by the production throughput of 1 cryomodule / week

Reference procedures will benefit on other projects:

- assembly of long cryomodules
  (e.g. 15 m long SPL cryomod.)
- clean room assembly
- cavity preparation

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Many thanks to all the colleagues from Saclay and DESY who have compiled all the documents (and much more …) presented in this talk

Special thanks to: S. Berry, C. Madec and O. Napoly

and thank you for your attention