SPL main power coupler

integration requirements

Eric Montesinos
CERN / BE-RF-SR

SPL requirements

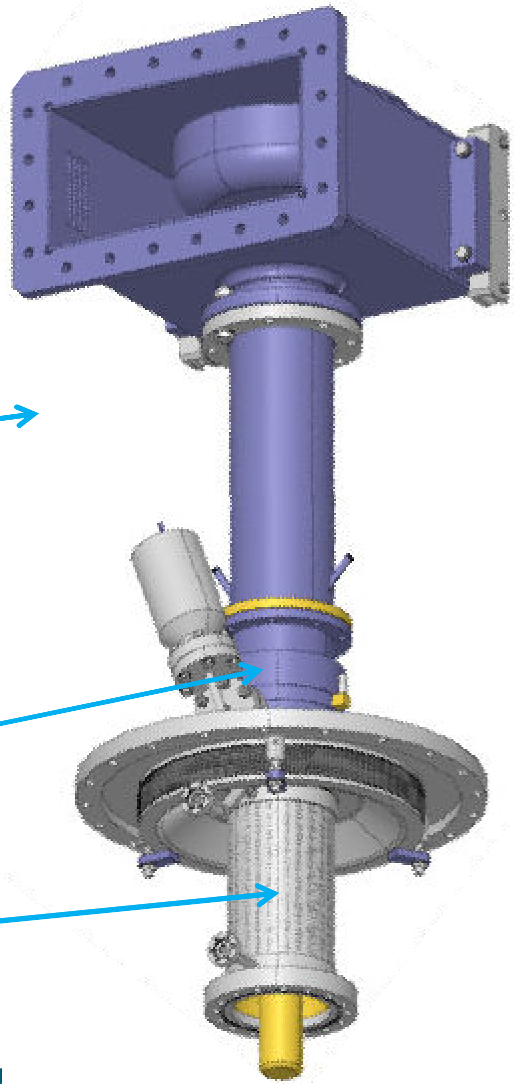
f_o	704.4 MHz
Low Power SPL	2.5 kW average 600 kW pulsed 0.4 + 1.2 + 0.4 = 2.0 ms 2 Hz (500 ms)
High Power SPL	100 kW average 1000 kW pulsed 0.4 + 1.2 + 0.4 = 2.0 ms 50 Hz (20 ms)
Cavity design gradient	19-25 MV/m
Q_{ext} of input coupler	$1 . 10^6$ for LP-SPL and HP-SPL
Input line Ø	100 / 43.5 mm = 50 Ω
Waveguides	WR 1150

Source : https://twiki.cern.ch/twiki/bin/view/SPL/SplWeb

Proposed design

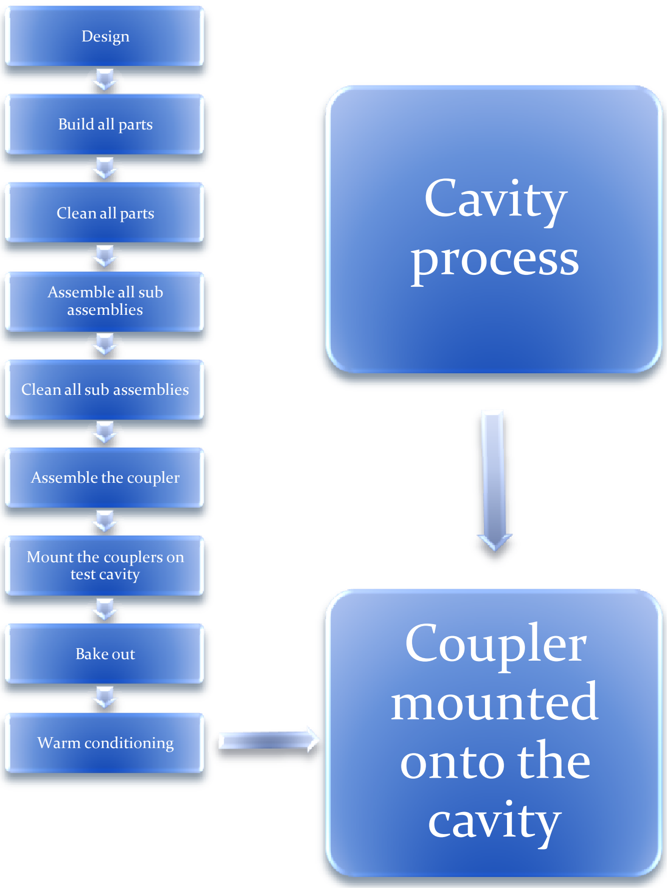
Coupler Working Group's conclusions:

- For mechanical reasons, easier to have the coupler mounted vertically, less stress to the antenna
- Preferably above the cavity, allows a good access, also the preferred solution for the tunnel integration
- Access from the bottom is less convenient for work with the air side and for connecting the waveguides
- Only one ceramic (very important impact onto the cavity assembly process)
- To ensure the thermal transition, a double walled tube will be connected between the cavity and the cryomodule (as already experienced with LHC, CEA Saclay)



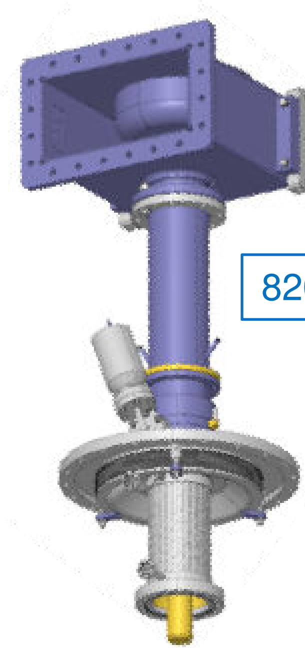
Coupler construction process

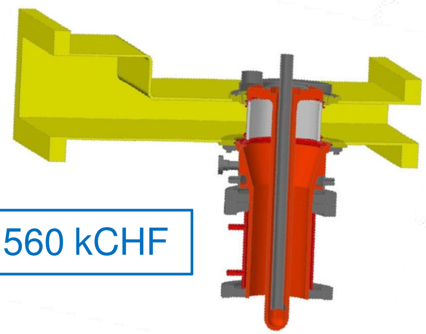
- The coupler is a component built in stand alone mode :
  - Design
  - Build all parts
  - Clean all parts
  - Assemble all sub assemblies, mainly in clean room
  - Clean all sub assemblies
  - Assemble the coupler, mainly in clean room
  - Mount it on a test cavity
  - Bake it out
  - RF conditioning
- Then only, the coupler is delivered to be connected to the cavity and its cryomodule

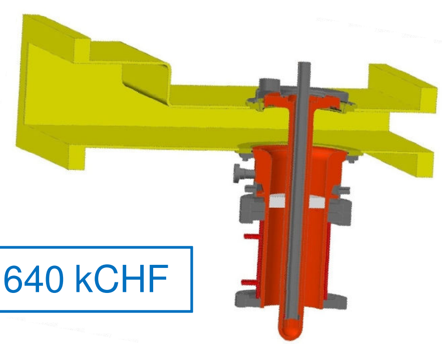


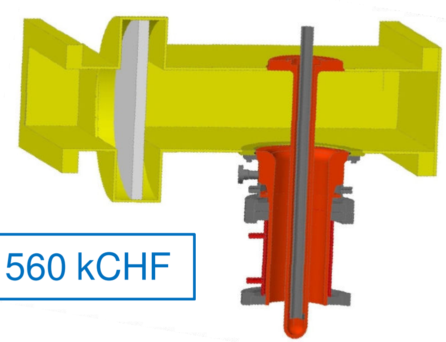
Design

- Baseline: CEA Saclay coupler
- However, to be upgraded for SPL cryomodule compatibility
- We also keep open the possibility to use another design, this is under study and we decided to fix it at the latest in March 2010 (LHC cylindrical ceramic, SPS coaxial ceramic SPS waveguide ceramic)
- Comparison basis:
  - RF power capability
  - Low heat load
  - Tuning capability (fixed coupling, adjustable coupling)
  - Conditioning time
  - Contamination during beam part assembly
  - Easy installation
  - Integration with the cryomodule
  - Easy operation
  - Cost



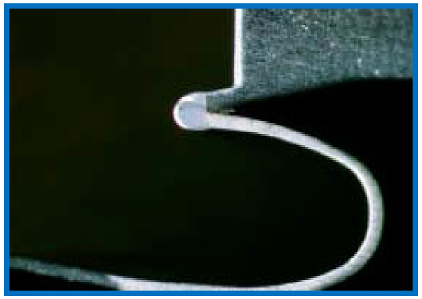






Build all parts

- Ceramic / copper brazing
  - ceramics are received metalized from WESGO, at least 3 months delivery delay
  - Brazing for small quantity at CERN, at least 3 month delivery delay
- Copper plating
  - Double walled tube already developed in collaboration between CEA and Sergio
- EB welding
  - Specifications, 100% penetration, tests to be done to optimize parameters
  - Design of removable masking tooling
- TIG welding
  - Dedicated specific welding bench is necessary
  - Validation of prototypes, tubes of different diameters
- Machining
  - Many specific components and tooling

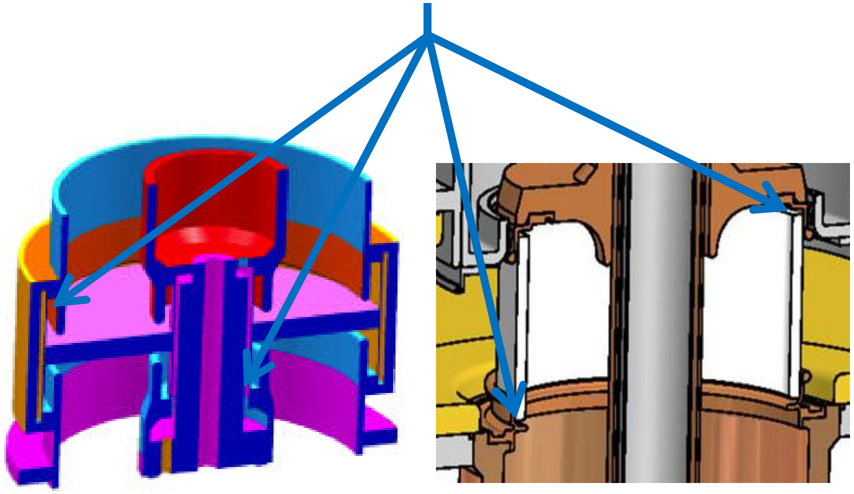


Assembly in clean room

- Clean all individual components
  - As we want to achieve a high gradient field of 19-25 MV/m, all the individual components in contact with the vacuum side shall be cleaned under a baldaquin with pure water and alcohol (LHC process)
- Assembly tooling, some necessary tools:
  - for assembly of stainless steel parts, ceramic braze, laser welds, Copper plating
  - for length adjustments, dimensional controls
  - for leak tests and desorption controls
  - for handling and storage, transport containers
- Handling, transport and cleanliness issues, specific precautions must be taken:
  - Clean assembly hall
  - Handling with special gloves only, avoid contamination of surfaces by hydrocarbons, finger prints,…
  - Minimize number of transports (to subcontractors) and number of handlings
  - Intermediate storage of parts in cabinets filled with N_2, intermediate packing in non-polymeric sealed bags with N_2
  - Transport containers specially designed (air tight, mechanical supports)

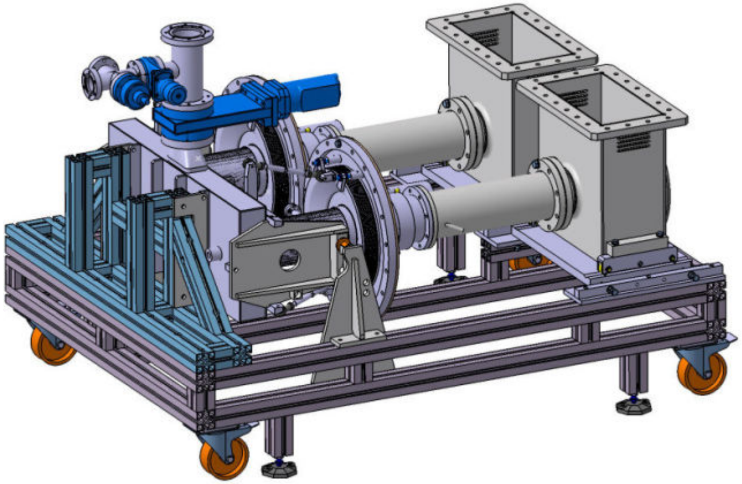
Clean all sub-assemblies

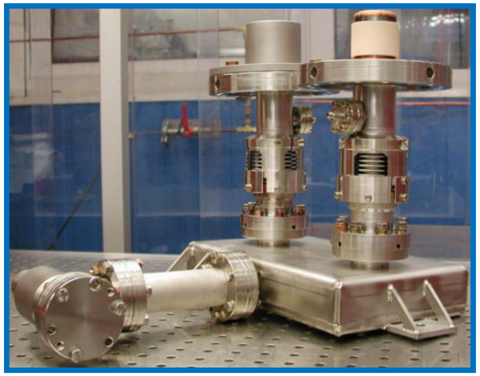
- All the sub assemblies in contact with the vacuum side shall be cleaned under a baldaquin with only pure water or pure alcohol
- After these operations, no more water or alcohol rinsing neither any chemistry allowed to the coupler to avoid any contamination in long term scale



Mounting on test cavity

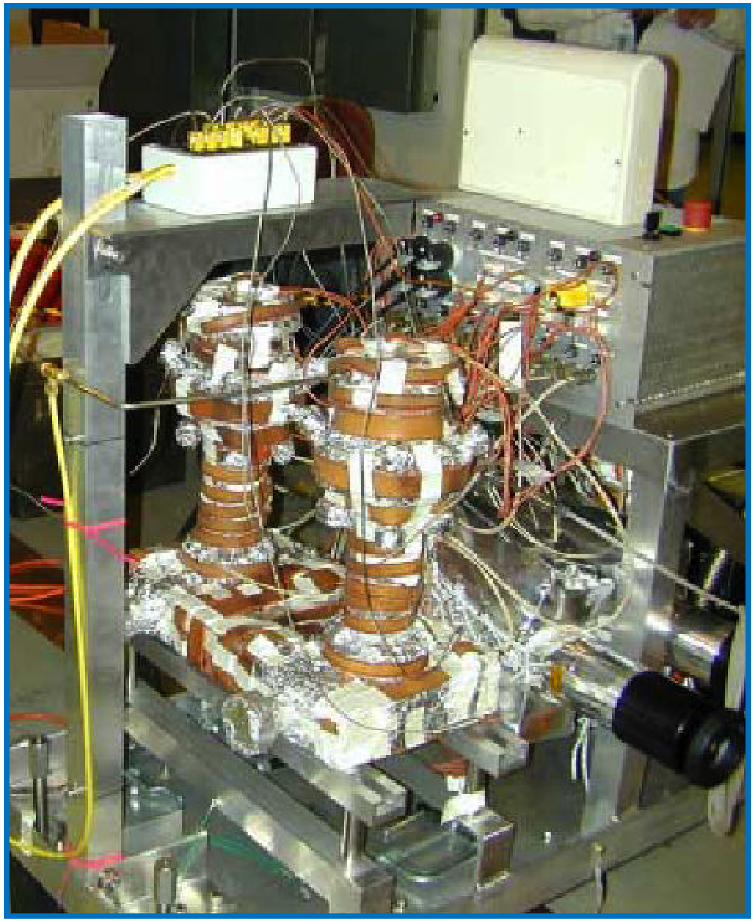
- In a clean room, the couplers are assembled and connected to the warm test cavity



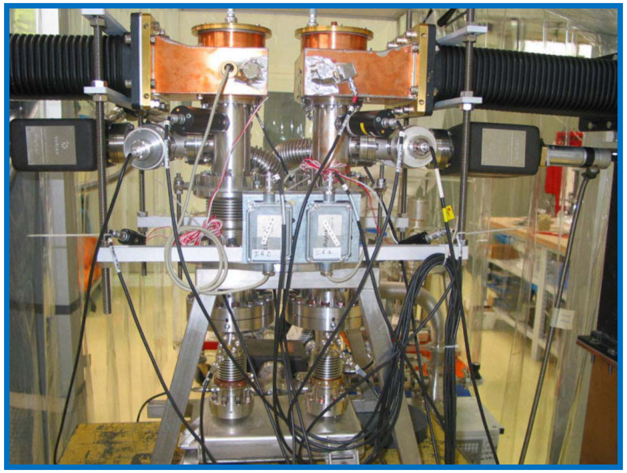
Bake out

- While assembled, each coupler is baked out
- Initial bake out for gas desorption and mechanical test, it enables a faster and efficient RF conditioning process
- This shall be done directly on the tests cavity to avoid any post conditioning contamination



Warm tests and RF conditioning

- Warm RF conditioning
  - Define a protocol for what is a conditioned coupler, based on the LHC experience
  - Check the reliability of the couplers
- Couplers are ready to be delivered



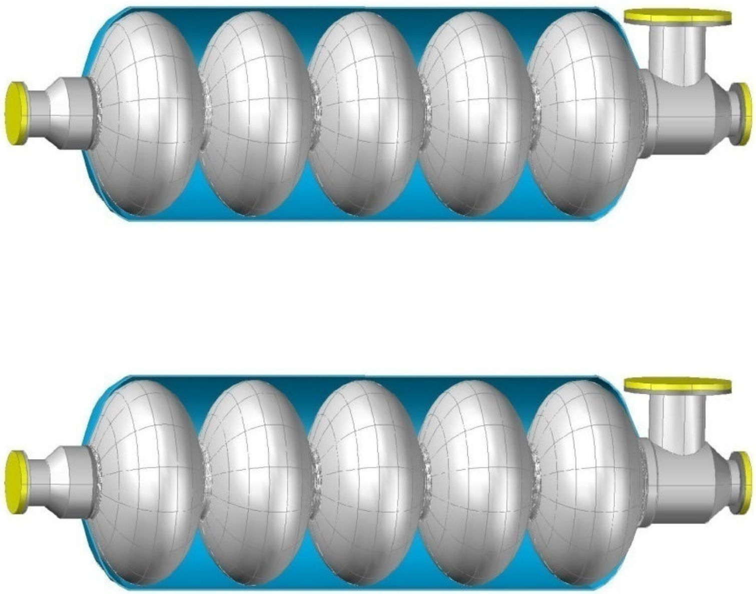
Cavity process

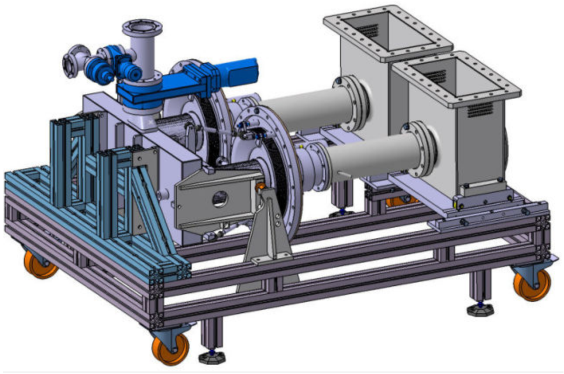
- In parallel, the cavity has followed its own cleaning process and fulfill all the validation measurements
- It has been mounted in its helium tank
- The cryomodule has been built and is also ready for mounting



Mounting in clean room (1/3)

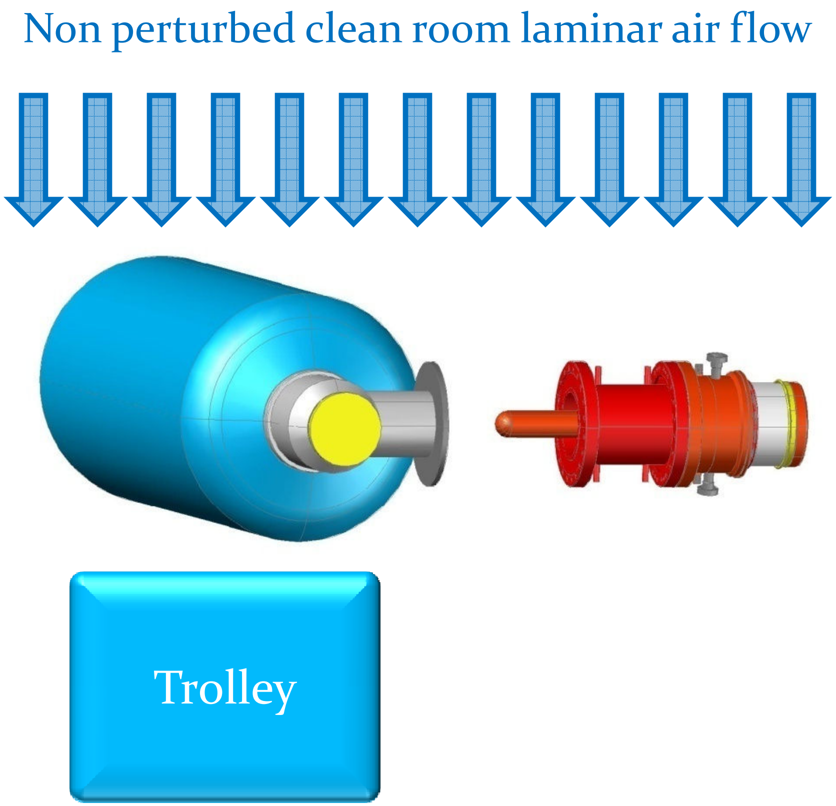
- The SPL cavities with their helium tanks and the warm test cavities assembly with their couplers are brought into the CERN's SM18 clean room





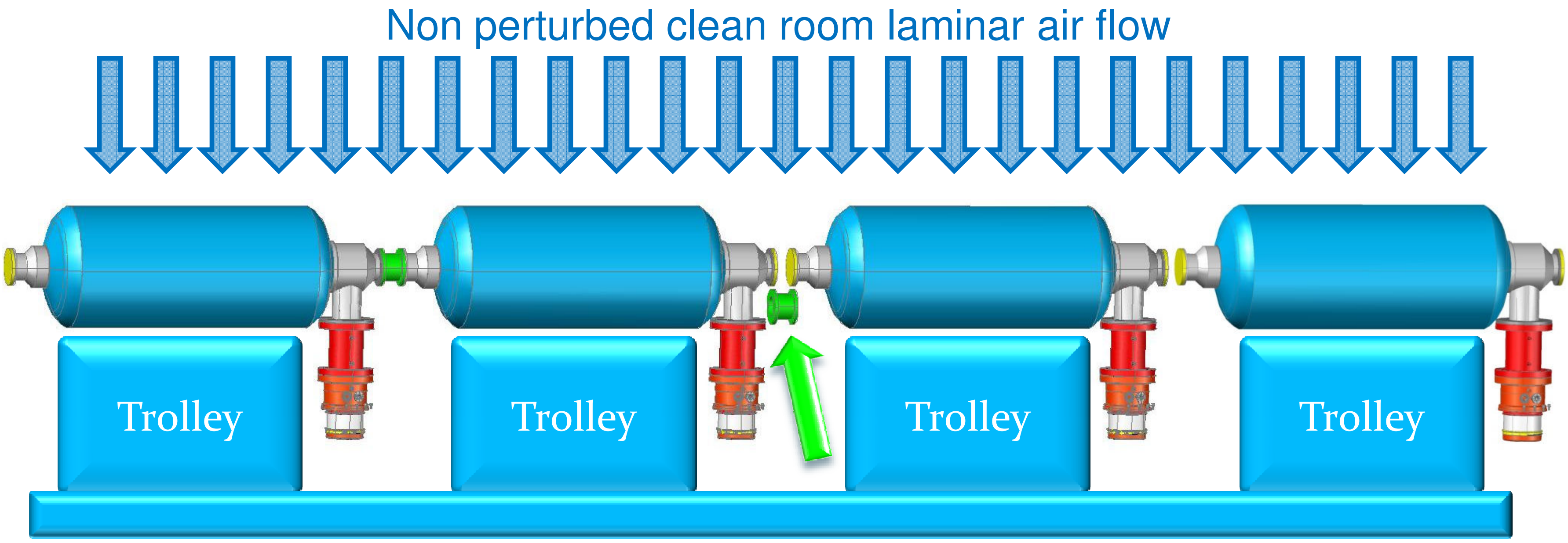
Mounting in clean room (2/3)

- Disconnect the double walled tubes with their couplers from the warm test cavity
- This will be a critical step because we will have an exposure to air over the already RF conditioned components and the cavity
- It is very important to do it with a very clean process to preserve high gradient field of the cavity
- Would prefer to do it with an horizontal position to minimize the pollution of the vacuum parts, using a non perturbed clean room laminar air flow
- Repeat these operations for the number of cavities to be mounted in one cryomodule



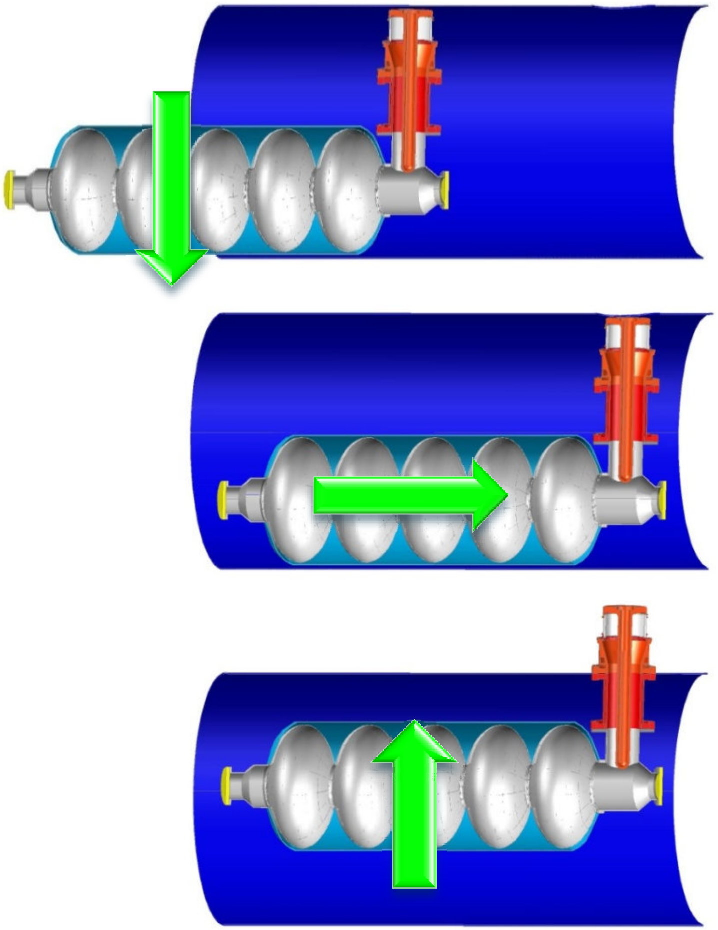
Mounting in clean room (3/3)

- Connect all the cavities together (with couplers oriented to the bottom for no contamination and better access ?)
- End of clean room operations

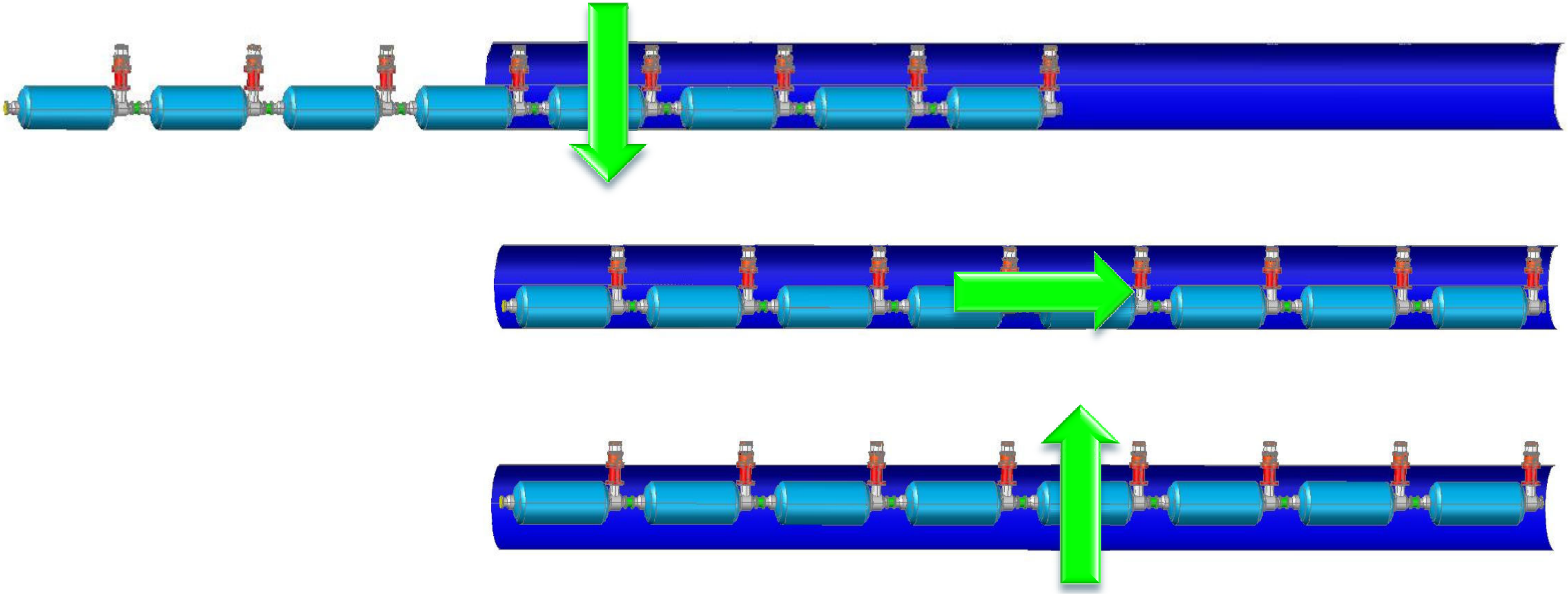


Mounting outside the clean room (1/3)

- The cavities are then oriented with the couplers above in a vertical position
- The cavities are equipped with all their isolation materiel and cabling
- Because the total length of the coupler, a special tooling/trolley must be designed for:
  - Moving the cavities at the bottom side of the cryomodule
  - Then put them in place longitudinally
  - And finally adjust them vertically

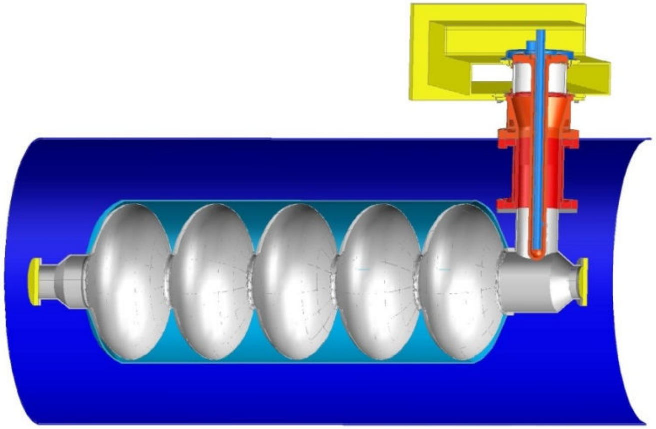


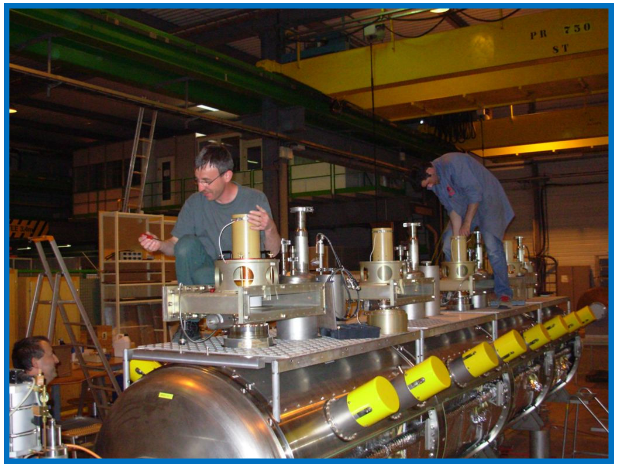
Mounting outside the clean room (2/3)



- This has to be done with a train of 8 cavities (+ 2 quadrupoles)

Mounting outside the clean room (3/3)





- Finally, the air side of each coupler is assembled
- The SPL cryomodule is ready for tests

Cryomodule connectivity

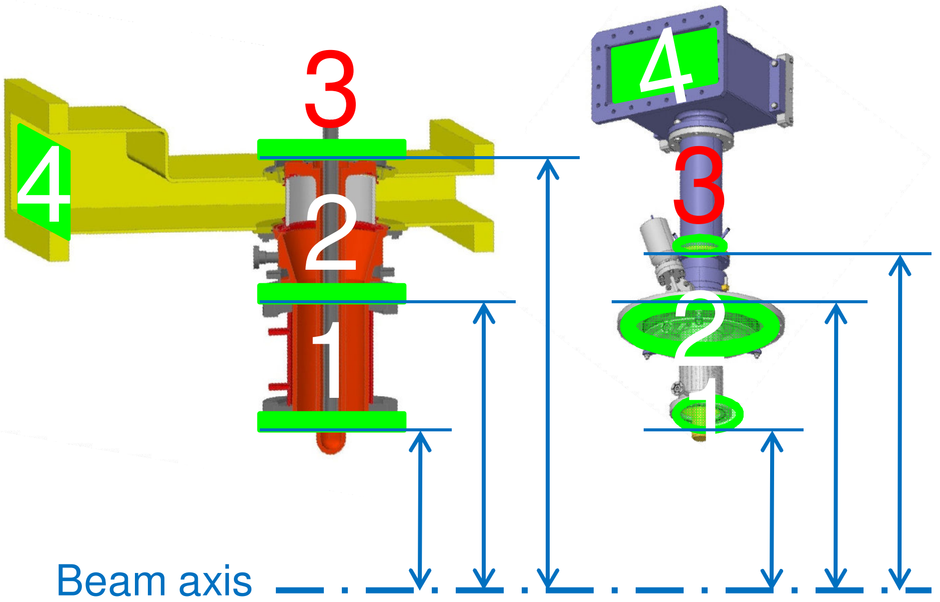
- Prior to all that process, including the design of the coupler, the main interfaces still have to be decided as soon as possible:

  1/ Cavity flange, lower part of the double walled tube

  2/ Cryostat flange, upper part of the double walled tube

  3/ Total height of the coupler for cryomodule integration

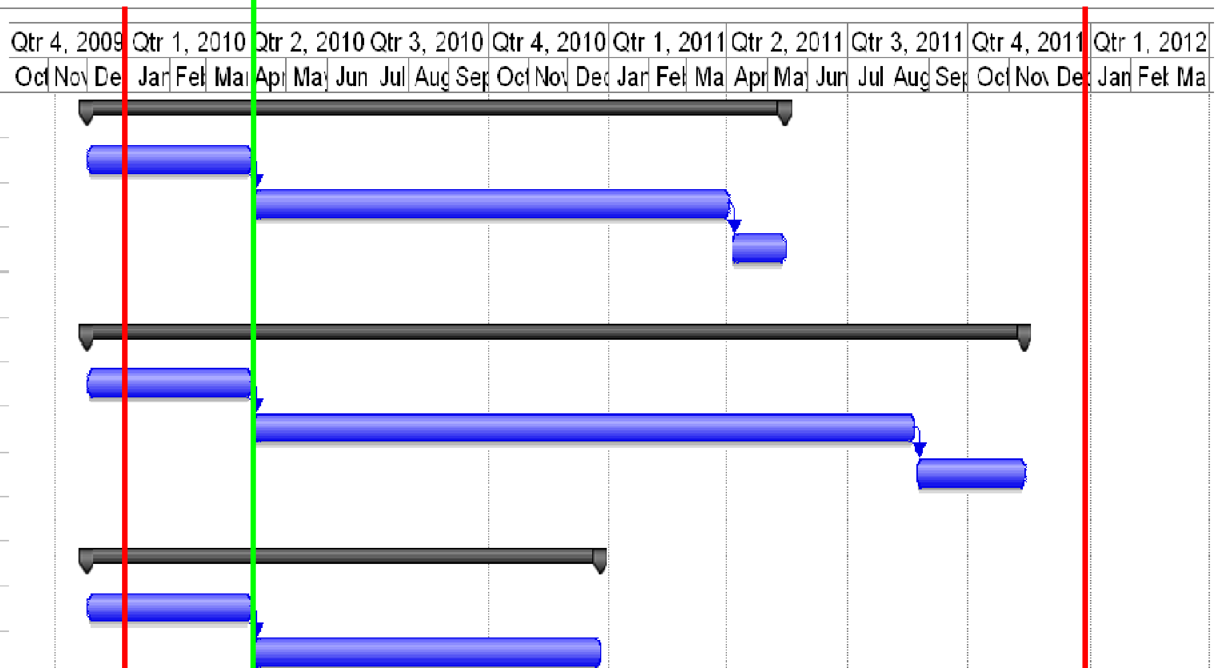
  4/ Waveguide flange, will impact on the waveguide distribution, and will define the needed supporting tool



Draft time table

Coupler design review
March 2010

ID	Task Name
1	SPL CEA Saclay couplers
2	Design modification for SPL cryomodule
3	Construction and assembly
4	Tests on warm cavity
5	
6	SPL Other designs
7	Design
8	Construction and assembly of chosen designs
9	Tests on warm cavity
10	
11	Warm tests cavities
12	Design
13	Construction and assembly

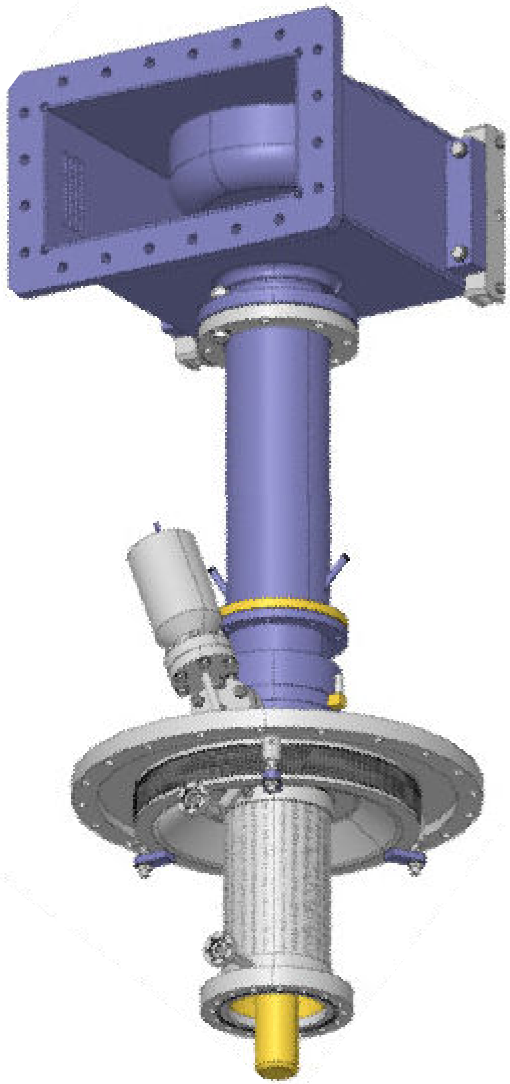


Interfaces definition
for end 2009

8 couplers fully RF conditioned
for beginning 2012

Conclusion

- For coupler needs (high average power):
  - One window power coupler
  - Vertical position (above)
  - Double walled tube
- For integration needs (high fields):
  - Horizontal mounting of the couplers in clean room
  - Each coupler directly mounted with its double walled tube in only one operation
- Flanges positions for end 2009



Thank you

- For the various advices, ideas, drawings, pictures, … many thanks to:
  - Stephane Chel and Guillaume Devanz (CEA Saclay)
  - Wolf-Dietrich Moeller (DESY)
  - Antoine Boucherie (CERN)
  - Many other colleagues…