



**«Cryostating» in SM18 or Elsewhere**

**or**

**«Cryo-module assembly» aspects (for SPS tests)**

V.Parma,  
CERN, TE-MS-C



# Outline

- «Cryostating» and Cryomodule assembly
- Clean-room and cryostat assembly considerations
- Limits of supply and consequences on assembly
- Need for CM intervention
- CM concepts (seen so far)
- Summary/Discussion



# “Cryostating” and Cryo-module assembly

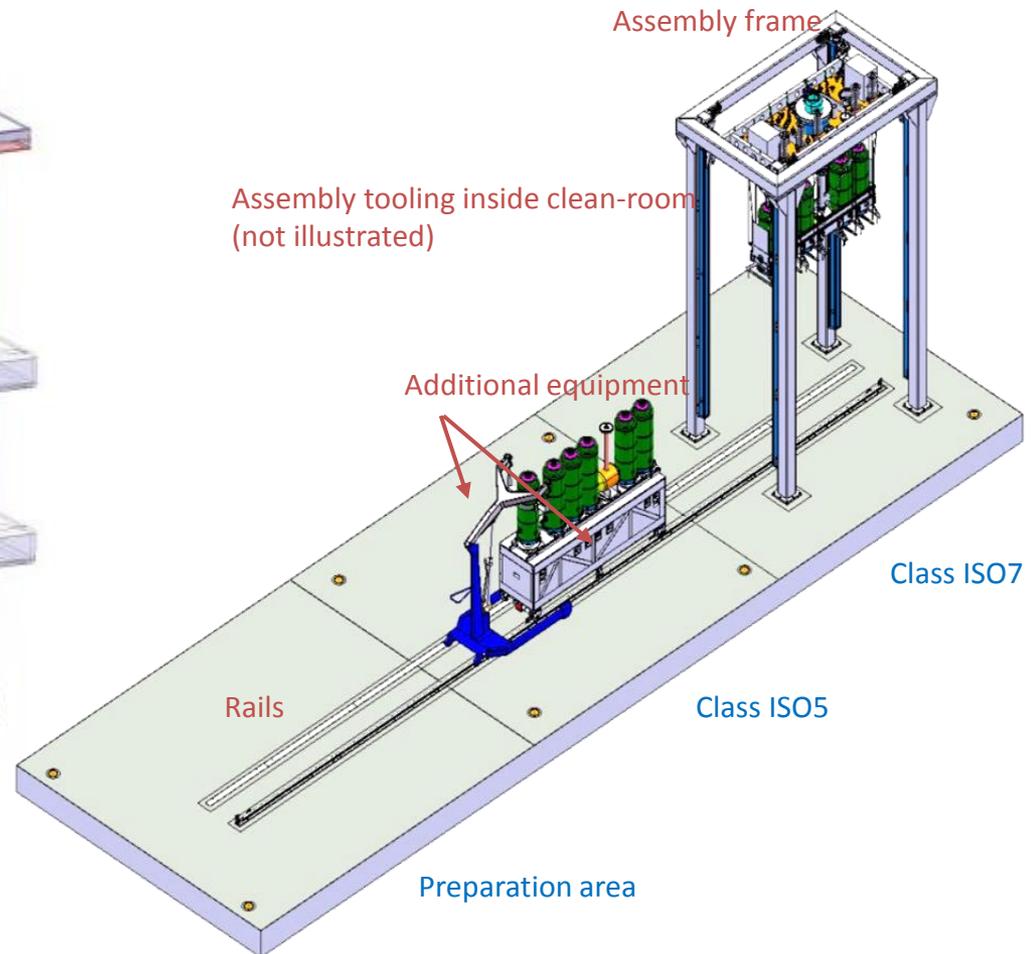
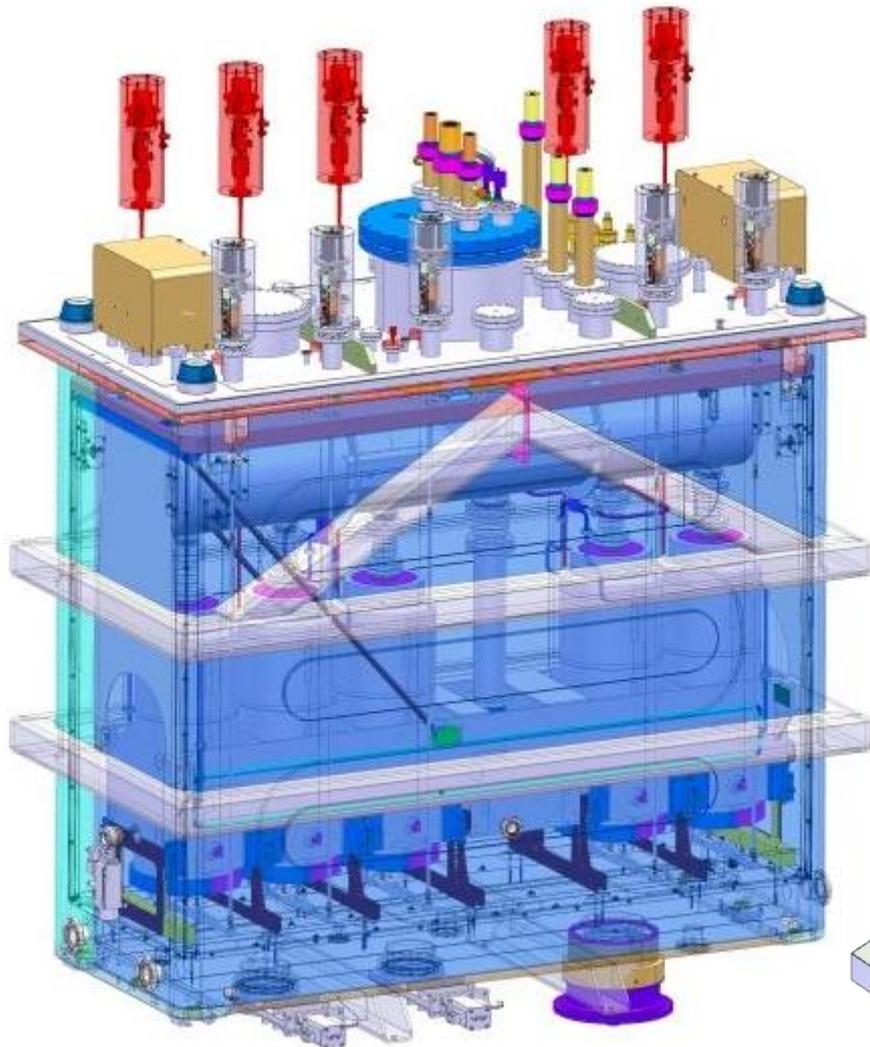
- “Cryostating” in magnets jargon means assembling the cold mass (and its ancillaries) in its cryostat
  - “Cryostating” a cryo-module means assembling a string of “dressed” cavities (previously assembled in a possibly adjacent clean-room), into its cryostat:
    - Examples: E-XFEL/ILC CM (and all those similar), SPL CM...
    - Exceptions: LHC CM, HIE Isolde CM, all assembly in a clean-room
  - Cryo-module assembly includes clean-room AND “cryostating” (or cryostat assembly)
  - High gradient CM require clean-room work to be separate from cryostat assembly
- Clean-room assembly and cryostat assembly should be dissociated but take place preferably close by (difficult and risky to transport a string of cavities over long distance!)

# Cryostat assembly of LHC quads



# HIE Isolde CM

Common beam/insulation vacua → cryostat assembly in clean-room



# E-XFEL/ILC CM



ILC CM



String inside the Clean Room

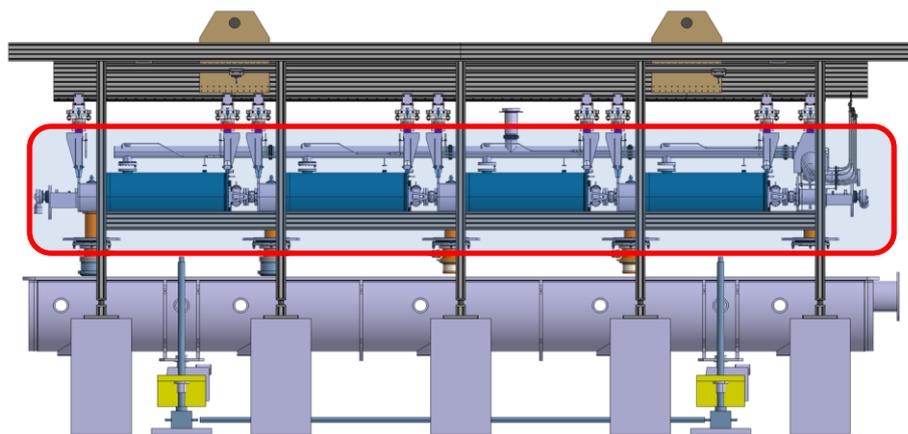
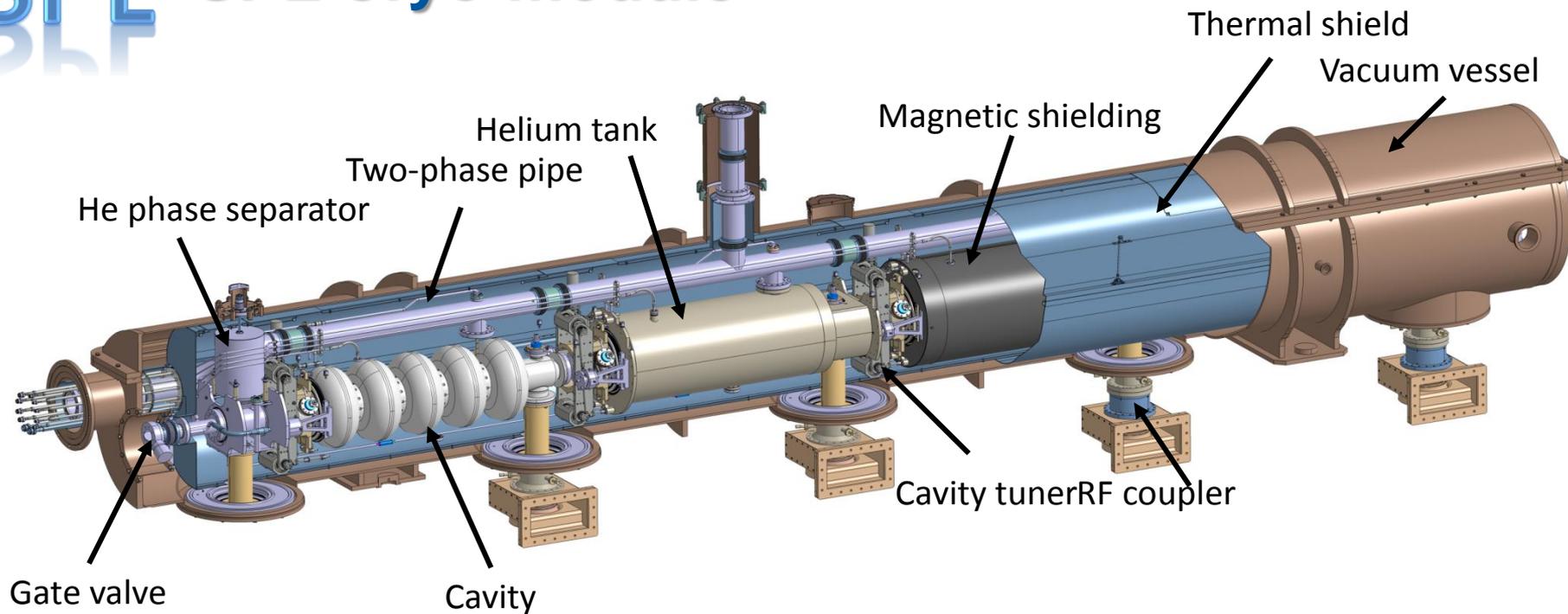


Sliding VV on shield (MLI)

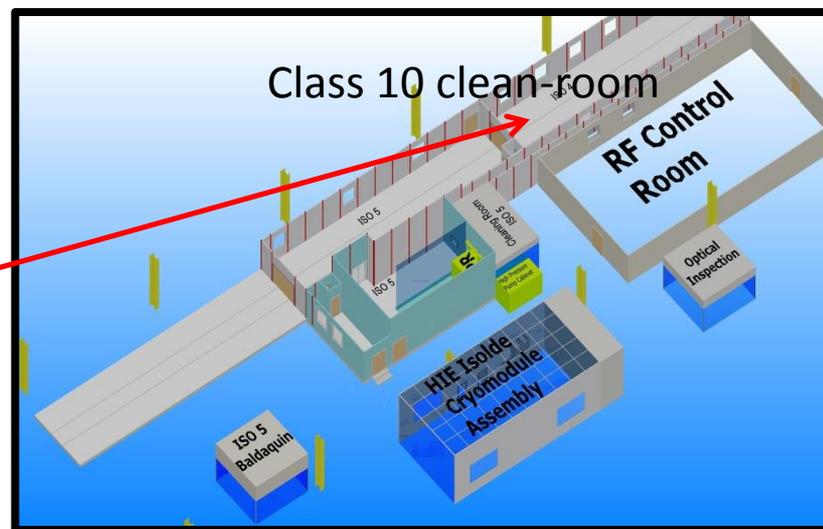


String on the cantilevers

# SPL SPL Cryo-module



Cryostat assembly in SMA18



String assembly in SM18

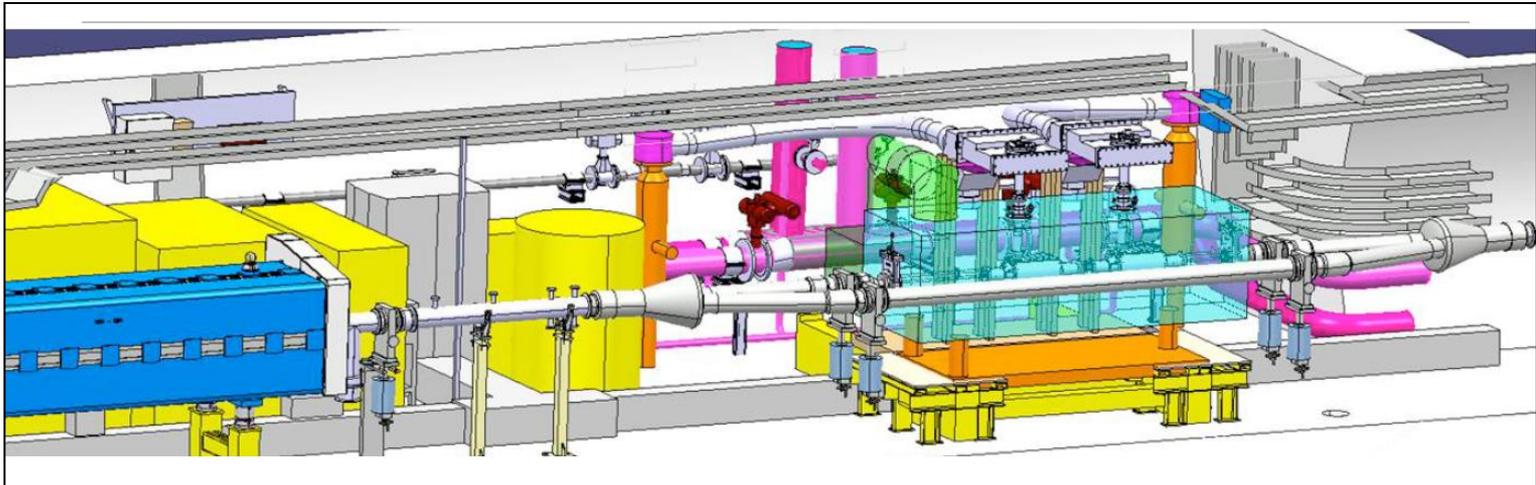
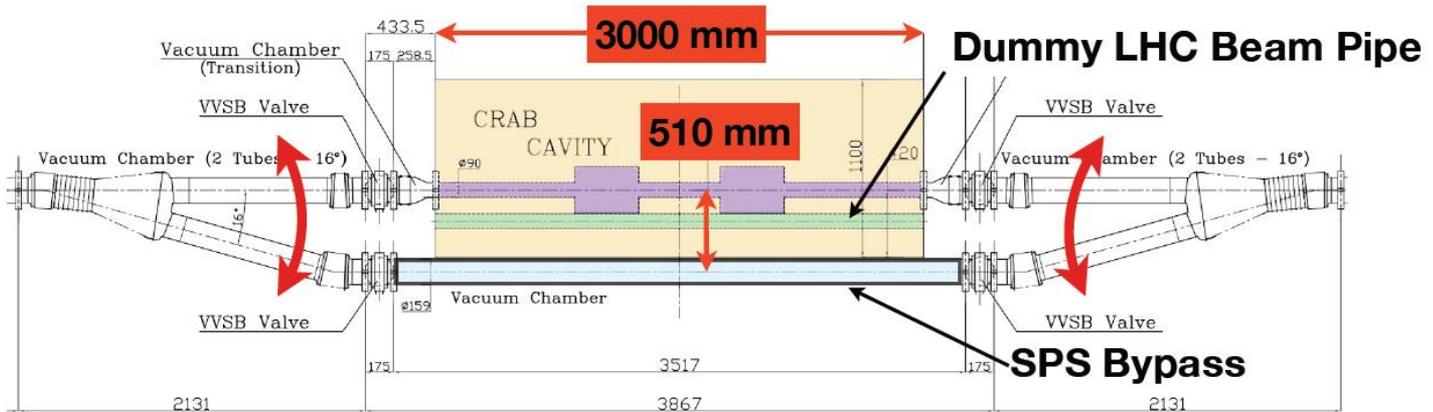


# Dissociating Clean-room work and Cryostat assembly

- Clean-room activity should be kept to a strict minimum:
  - “Dressed” Cavity + RF coupler + HOM + LOM
  - Cavities string + gate valves
- All the rest should be made during Cryostat assembly:
  - tuners
  - mechanical supports
  - magnetic shielding
  - thermal shielding
  - cryogenic circuitry
  - instrumentation
  - vacuum vessel
  - cryogenic interface to cryo-distribution
  - RF coupler interface to wave guides
  - ...

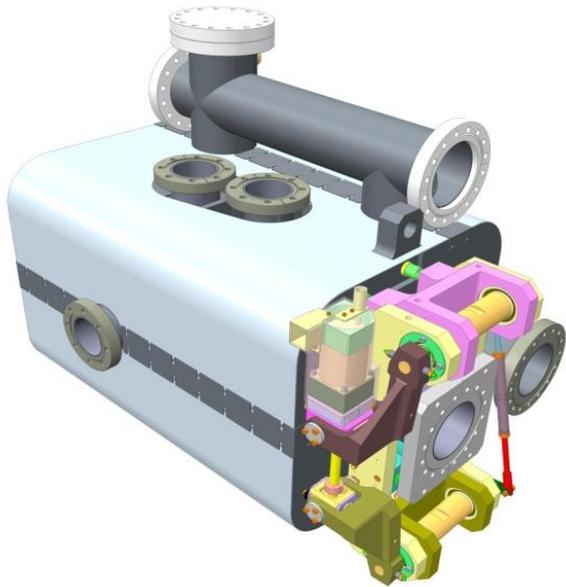
# SPS testing environment

=> Mechanical Y-Chamber mounted on support table

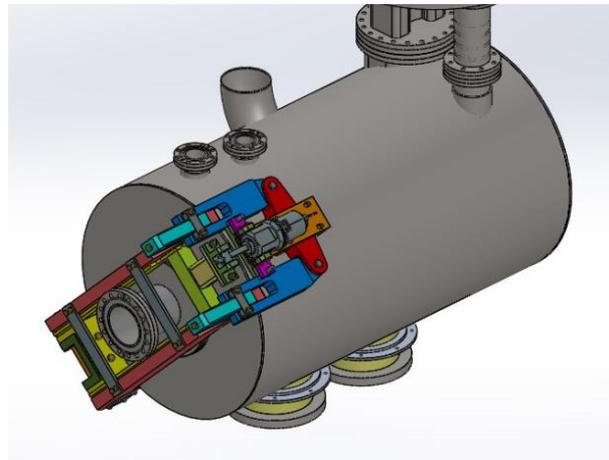


# 3 Candidates: dressed cavities

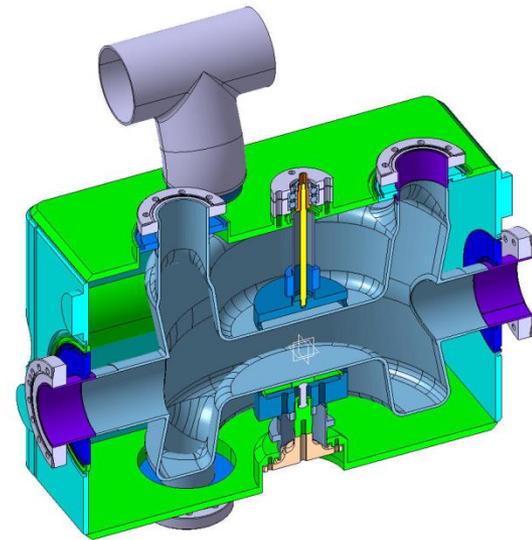
- Cavity + Helium tank + Tuner is a *minimum functional assembly* (+ eventually HOM/LOM) to be supplied
- The rest should be possibly *standardized* (i.e. common supply/assy method)



4-rod  
(UK)



RF Dipole  
(ODU)



Double 1/4-wave  
(BNL)



# Who supplies what ?

2 scenarios (at least):

- a. Each candidate cavity (x2) comes fully assembled in its CM (*any interest for labs to test their CM prior to shipping to CERN ?*)
- **Pros:**
    - direct testing in SM18 first (then in SPS), no bottle-neck in clean-room/cryostat assembly
    - no design-specific CM assembly (everyone makes his own)
  - **Contras:**
    - Transport of delicate assembly (but feasible)
    - CM as a “black box”: difficult adaptation/modifications/CM intervention at CERN (unless assy tooling, procedures and knowhow transferred too...*improbable!*)
- b. Each candidate comes as a dressed cavity (x2), and the CM assembly is made at CERN (string assy in clean-room + cryostat assembly in SM18)
- **Pros:**
    - full control on assembly, possibility of CM intervention at CERN
  - **Contras:**
    - SM18 work load: clean-room bottle-neck, cryostat assembly space in SM18. Specific knowledge about candidates needed. *Can it be done within allocated and resources?*

→ **Option b.** is most probably to be preferred



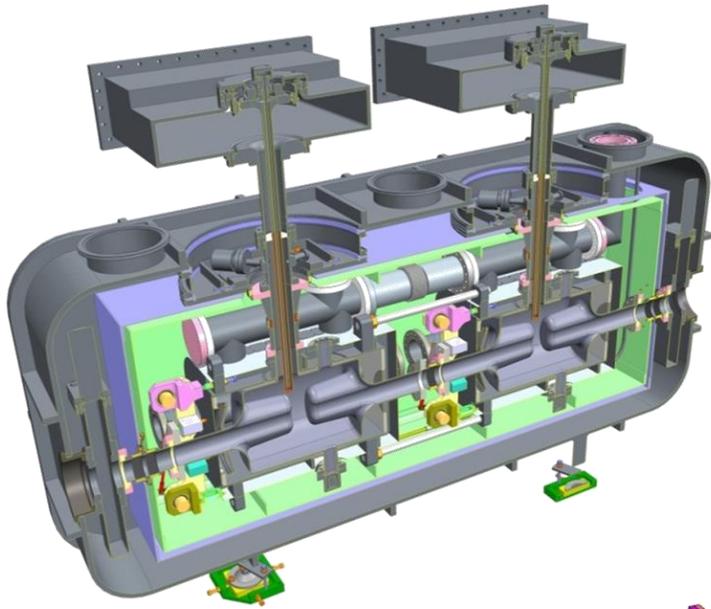


# CM design options

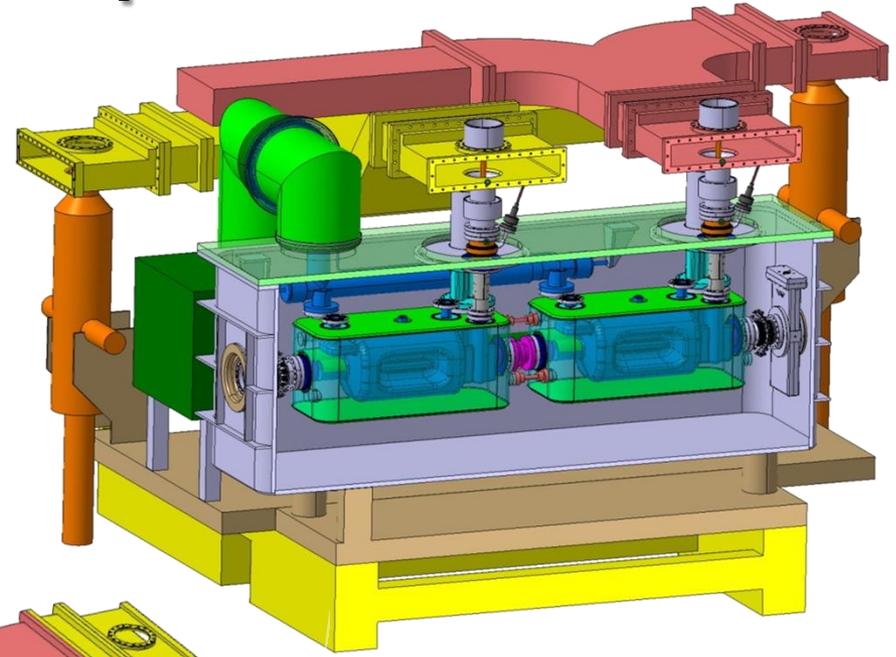
(assuming an assembly at CERN)

- Same CM design for all candidates?
  - Pros:
    - Standardization, → resource-effectiveness, time-saving
    - CERN has full control on CM activity (we need to know what gets into our machines!)
  - Contras: ?
    - Limits “freedom of expression” for cavity designers. Is it a showstopper ? (e.g. common RF tuner)
    - Requires some design compromise for the dressed cavity (interfaces, adaptations...)
- SPS *plug-in compatible* design?
  - Pros:
    - Minimal work-load in SM18 (if well prepared)
  - Contras:
    - Every CM assembly needs specific components/tooling/procedures → Heavy!
- Clean-room assembly:
  - In both case, the SM18 clean-room preparation will require cavity-specific tooling/procedures.
  - Some level of standardization should be tried (e.g. RF coupler assembly, gate valves, adaptation parts, etc.)

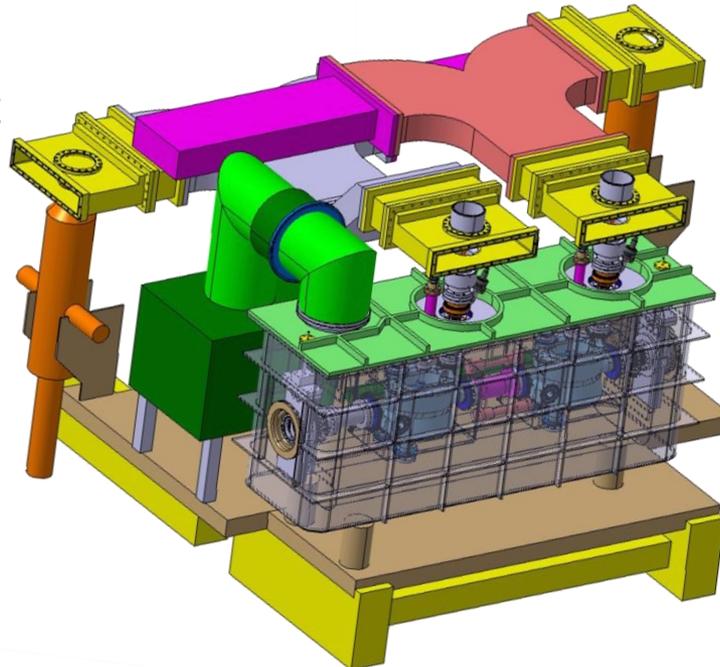
# SPS plug-in compatible CMs ?



4-R as seen by STFC



RF dipole as seen by CERN



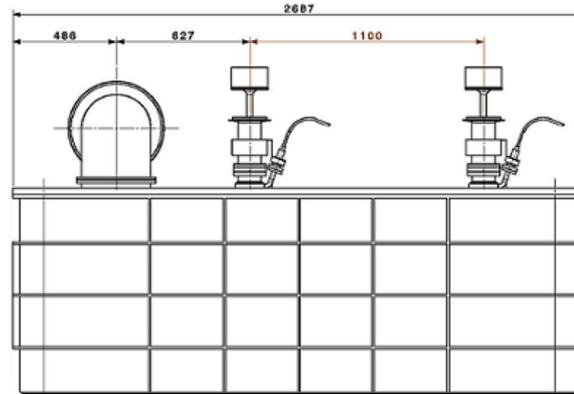
Double QW as seen by CERN

Courtesy of O. Capatina

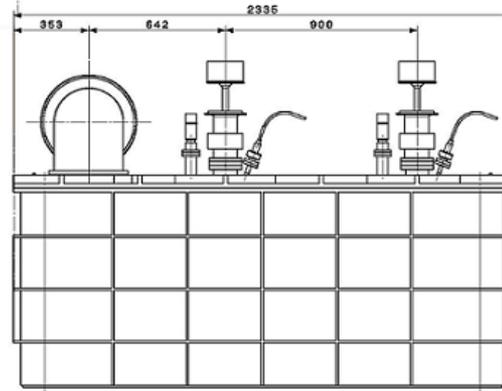
# Cryomodule

- Design principle, dimensions and interfaces (RF, cryo) to be standardized as much as possible
- Metric system !

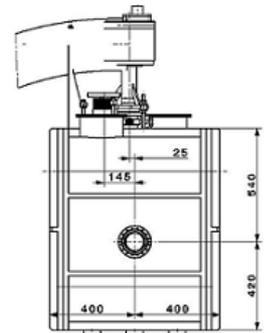
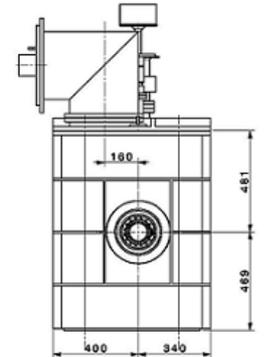
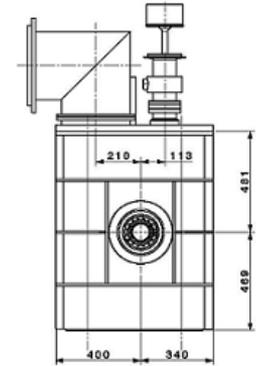
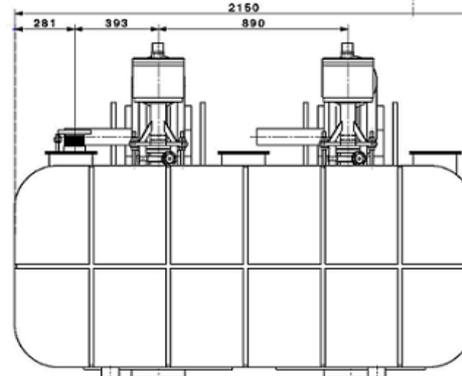
ODU



BNL



UK

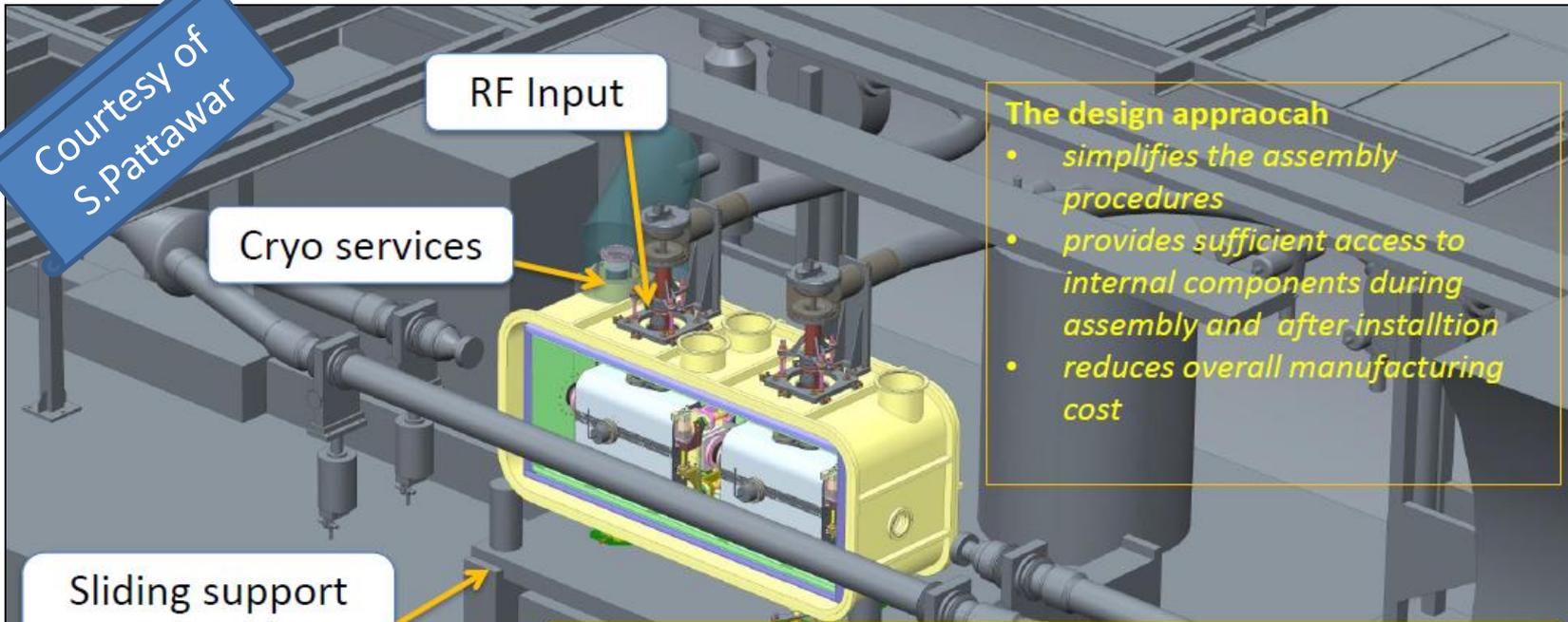




# Need for CM intervention ?

- SPS, in-situ intervention (limited time)
  - External connections/interfaces, limited (e.g. leaks, vac.gauges/pumps/helium level gauge replacement, etc.)
  - In-cryostat access (tuner repair, RF connectors) only if designed for (specific opening, procedures, needs VVU/venting, open thermal and magnetic shields...), heavy ! → disconnect and bring up CM preferable
- SM18, Bunker intervention
  - Like in SPS, but longer intervention allowed
- SM18, Cryostat assembly station intervention
  - All possible cryostat interventions (if foreseen with tooling/procedures, spare parts) except cavity intervention (return to clean-room)
- SM18, Clean-room intervention
  - All dressed cavity operations (if foreseen with tooling/procedures, spare parts)

# SPS intervention



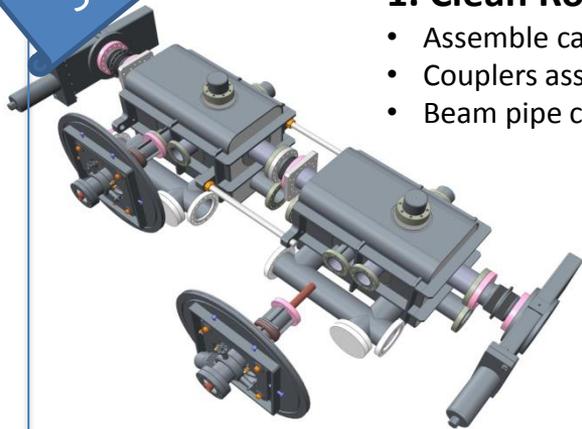
SPS in-situ intervention possible ? Accessibility, handling, ...

# Basic Assembly Sequence (4R)

Courtesy of  
S.Pattawar

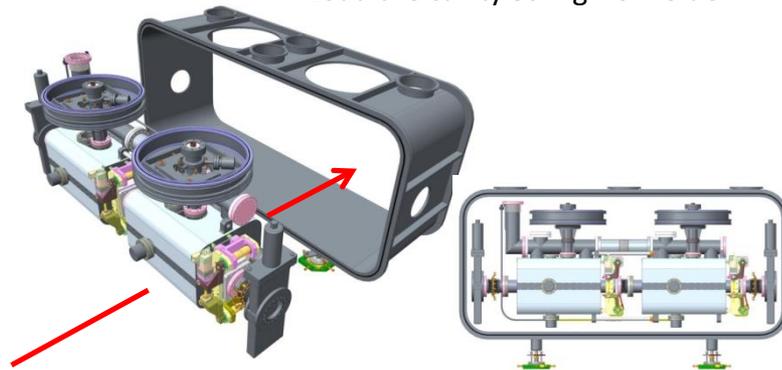
## 1. Clean Room Operations

- Assemble cavity string
- Couplers assembled at 90°
- Beam pipe closed with gate Valves



## 2. Outside the clean Room

- Load the cavity String from Side



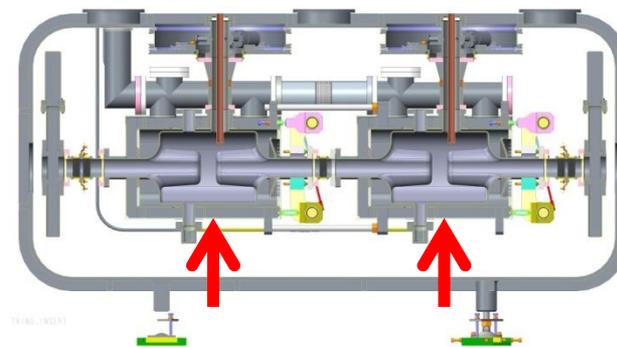
## 4. Align the string

with the outer tube adjustment system and a laser tracker.



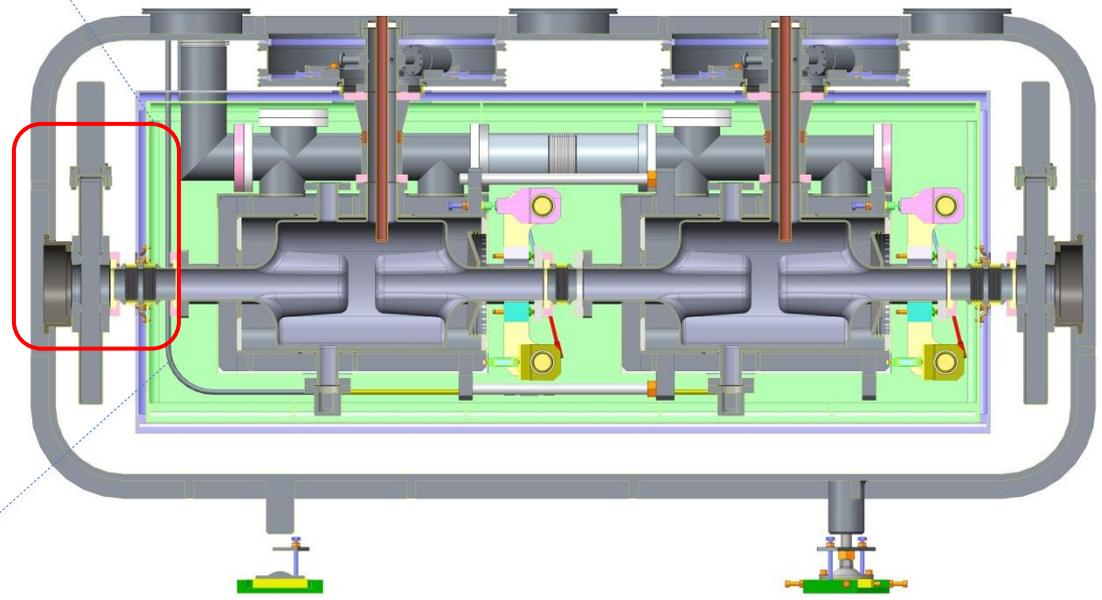
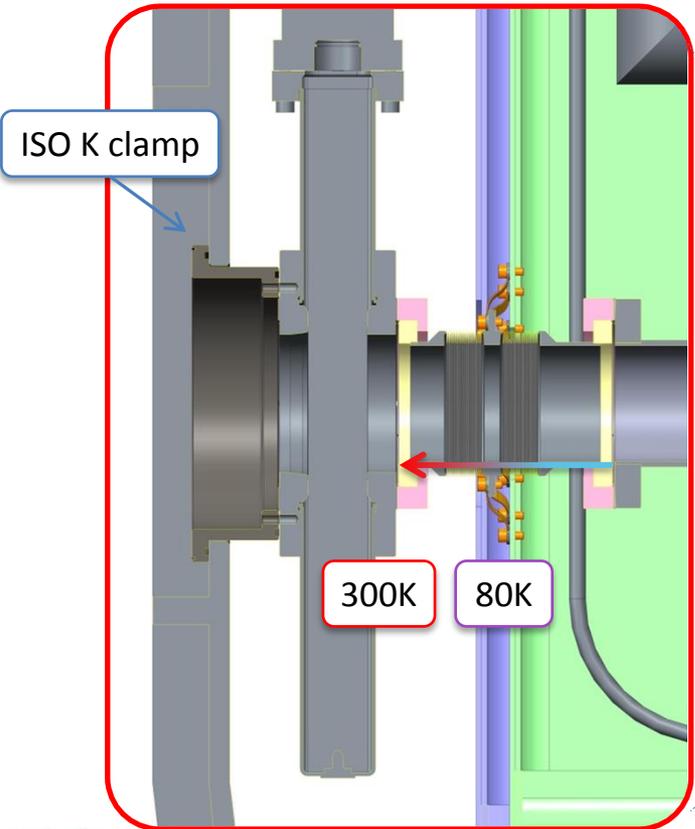
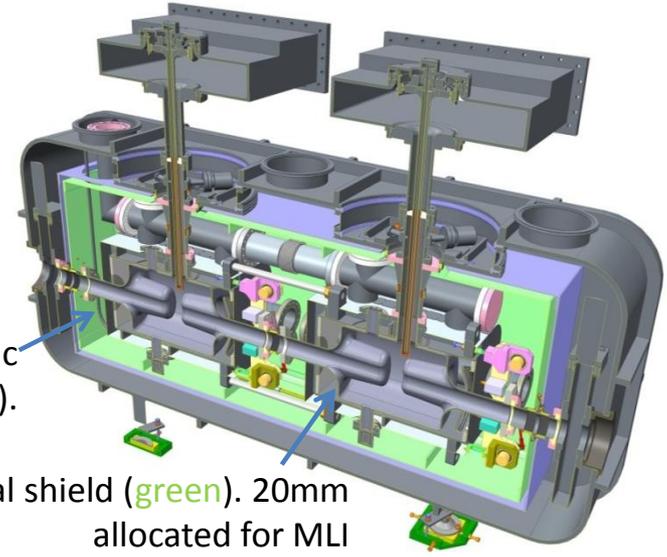
## 3. Lift and assemble

using sliding frame, or **lower** Outer Vacuum Chamber



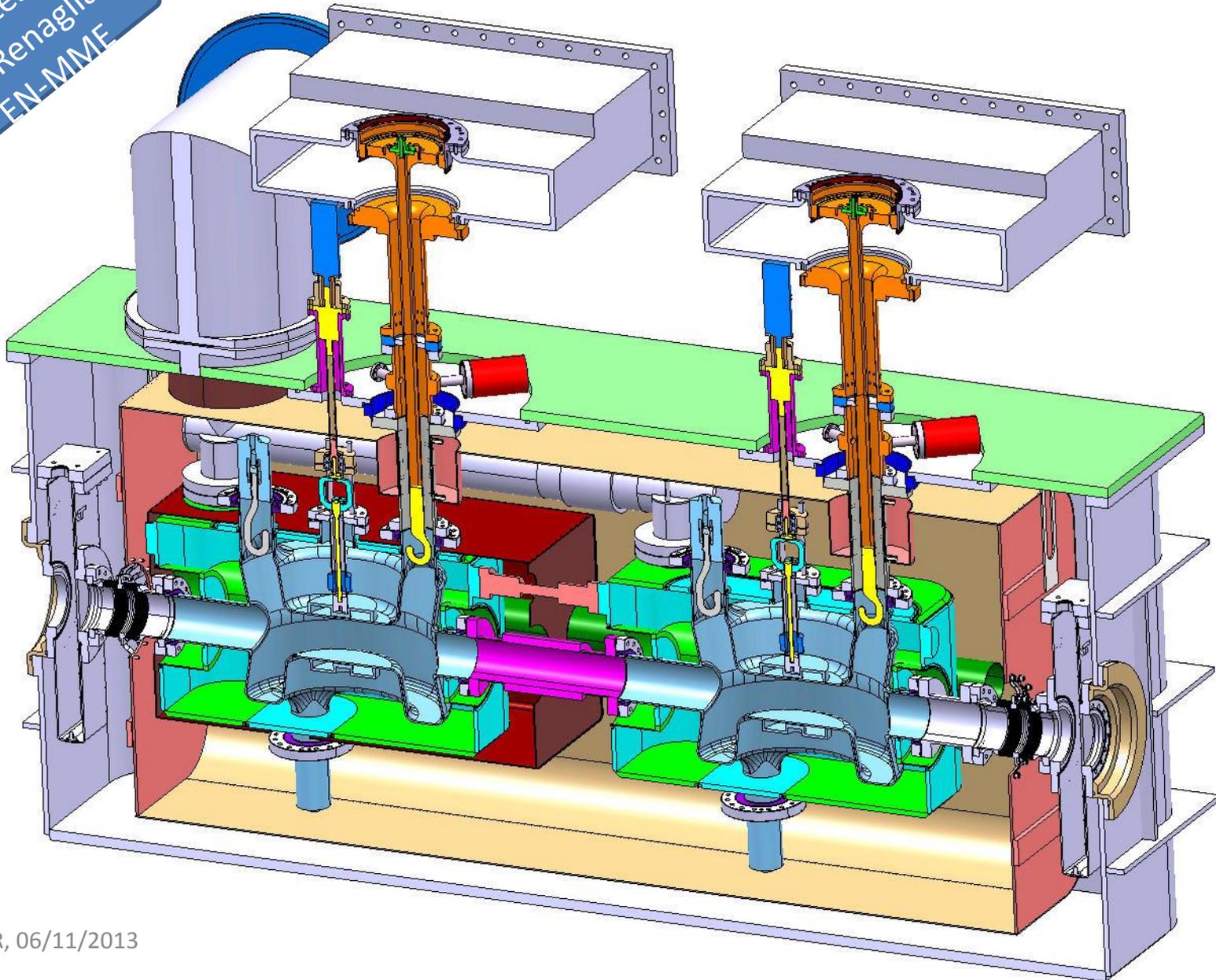
# Final Assembly

Courtesy of  
S.Pattawar



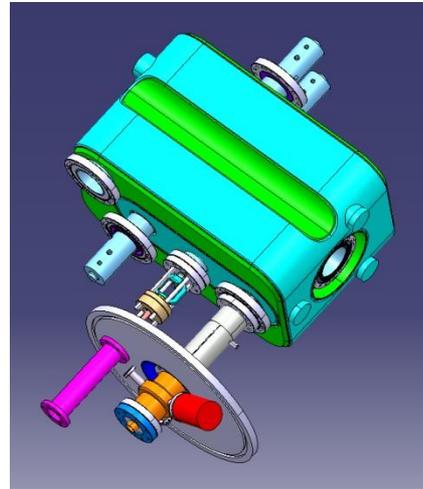
# Preliminary CERN studies of Double QW cavities in cryo-module *(similar study done for RF Dipole cavity)*

Courtesy of  
Th. Renaglia,  
FN-MME

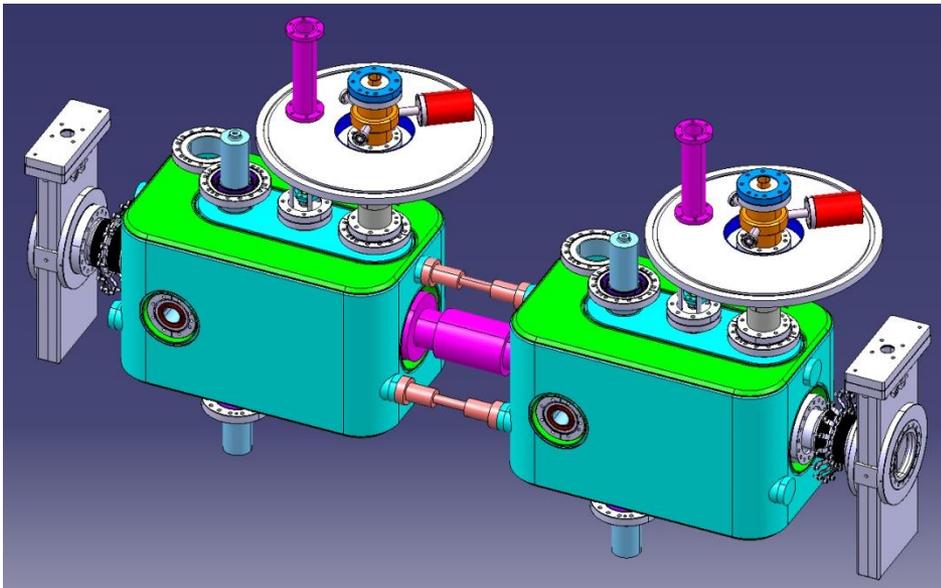




Courtesy of  
Th. Renaglia,  
EN-MME



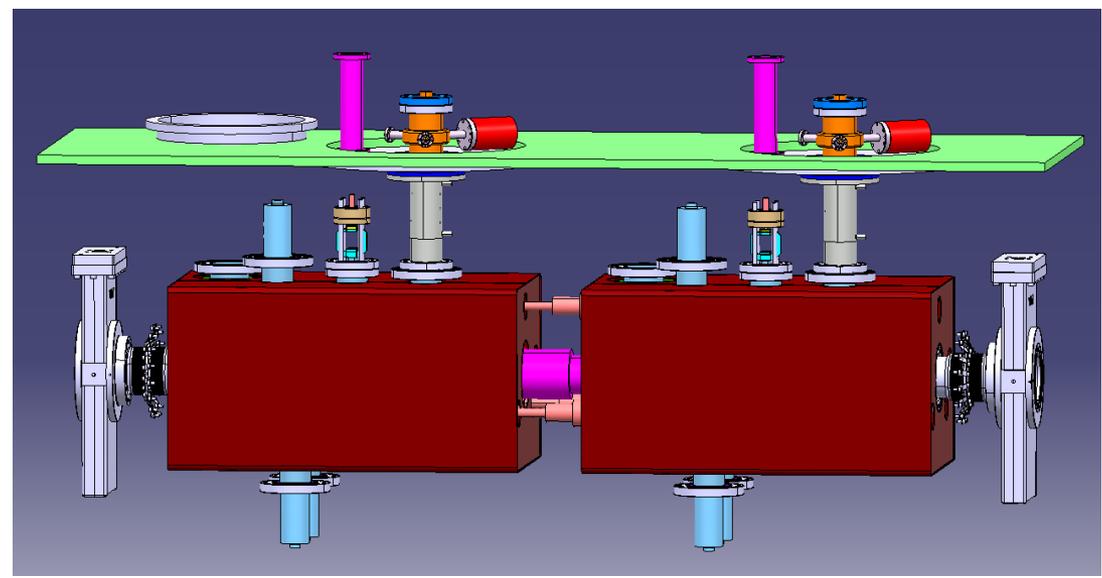
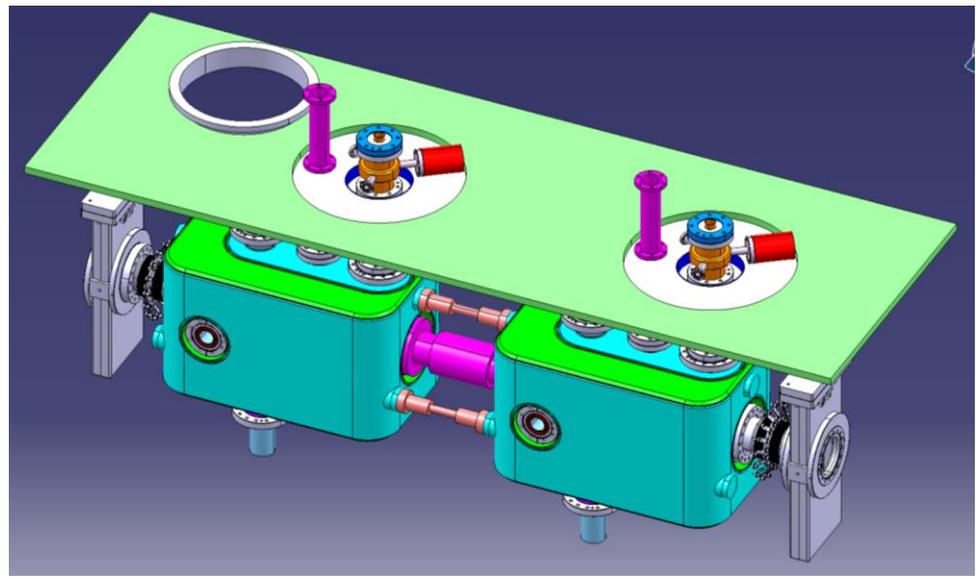
2)  
Cavity coupler assembly in clean room



3)  
Cavity + beam pipe + valve  
clean room assembly

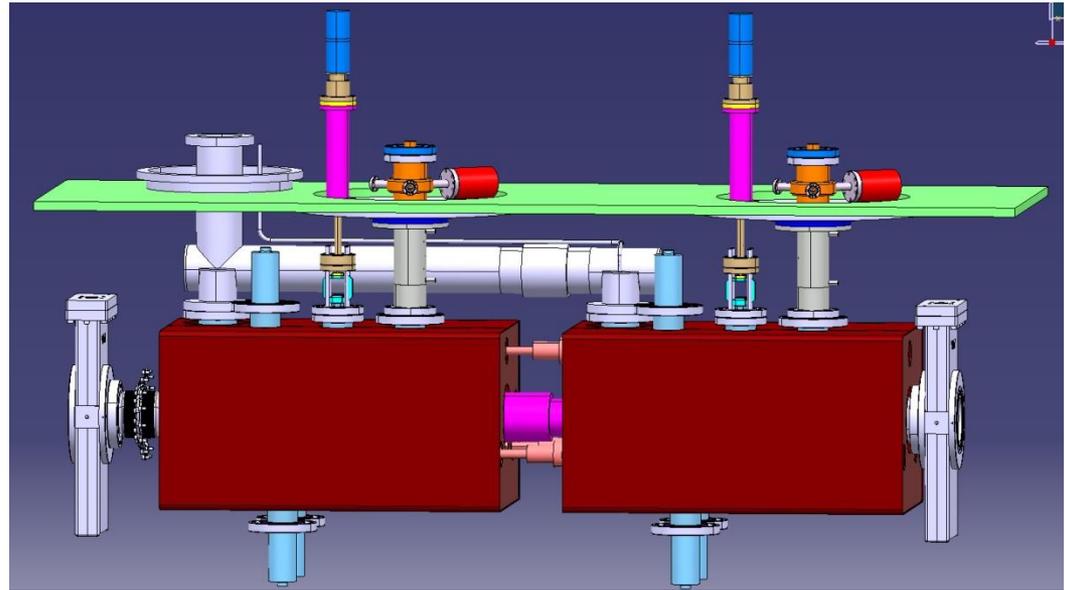
Courtesy of  
Th. Renaglia,  
FN-MME

4)  
Cryostat plate mounting + adjustment



5)  
Cold magnetic shielding assembly

6)  
Assembly of line to cryo supply +  
tuning system

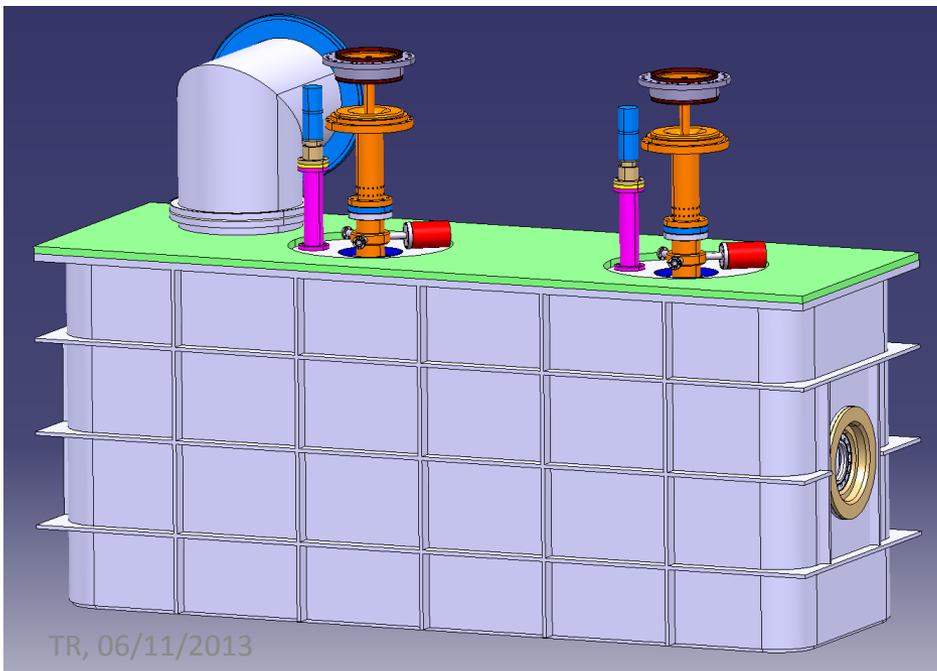
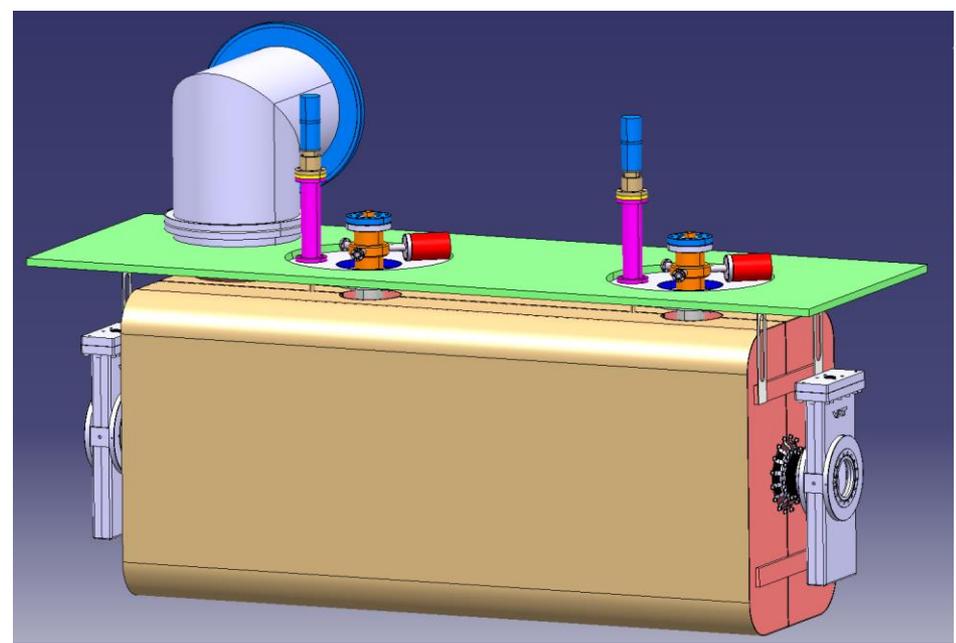


7)  
Thermal shield assembly +  
cryo connections



Courtesy of  
Th. Renaglia,  
EN-MME

8)  
Cryo connection



9)  
Closing the cryostat + RF connections



# Summary/Discussion

- Dressed cavity as a *minimum functional supply*? Agreed ?
- SPS *plug-in compatibility or identical CM*?
  - Are labs interested in prior testing a CM in their premises or not ? If not, better to focus CM engineering effort on one single design (with some compromise)
  - Considerable effort made in trying to standardize the CM design, but what stops from making it identical (the ideal solution) ?
- *CM intervention* considerations are essential (these are test units!):
  - SPS in-situ work ? Probably *limited*
  - *In-cryostat accessibility should be foreseen* (tuner, RF connectors repair, etc)
  - *CM dismantling for intervention?* Infrastructure needed (could be a *dedicated assembly space*)
  - *Cavity intervention needed?* Disassembly needs to be done in clean-room (*no choice!*)
- SM18 has all the needed infrastructure for CM assembly, but :
  - *Cryostat assembly space* should be identified (*SM18 or close by*)
  - *Clean room assembly* will remain cavity-specific, but a *standardization effort should be tried*
  - It is the *ideal place* for preparing for the SPS tests



**Thank you  
for your attention!**