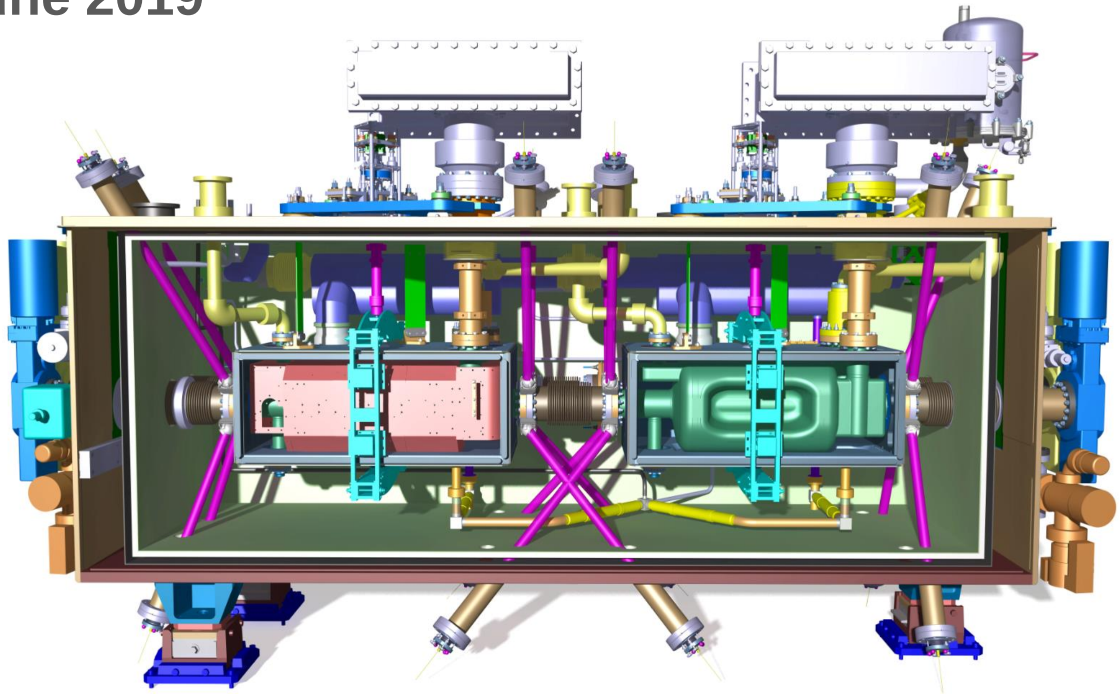
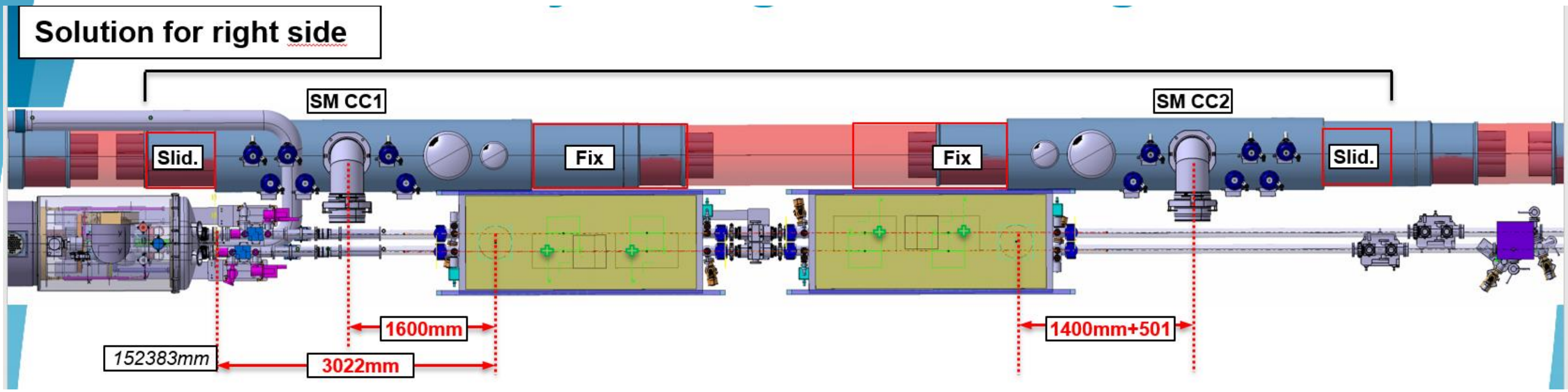
CERN / Triumf - Overview of cryomodule design
6th of June 2019

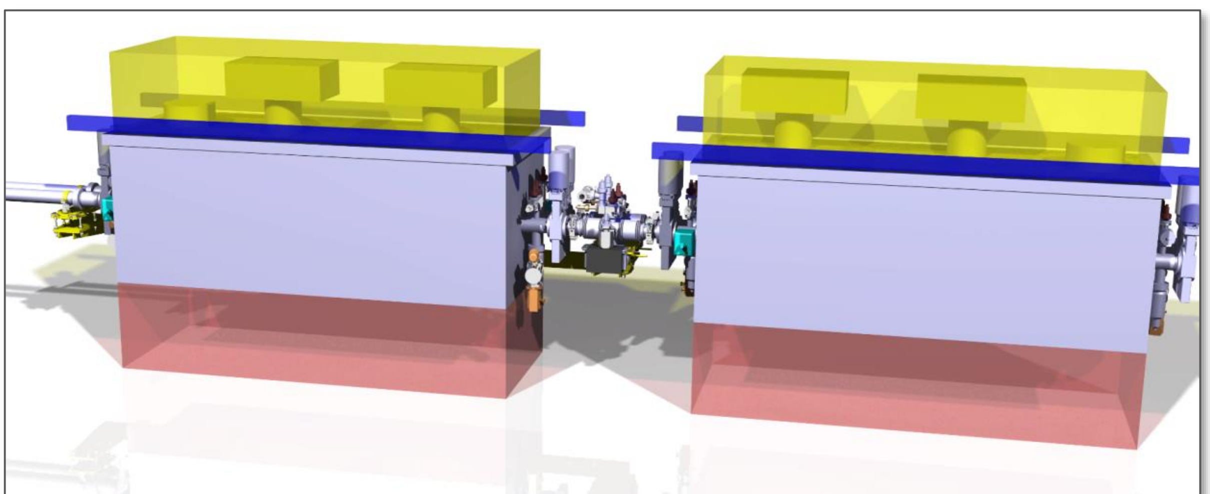


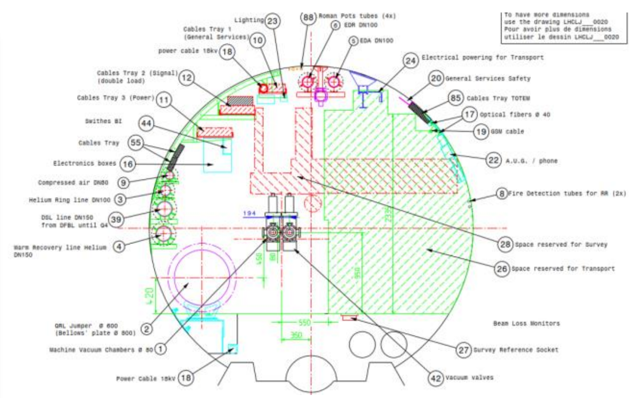
Teddy Capelli - CRAB Cavity design team – CERN

Integration LHC



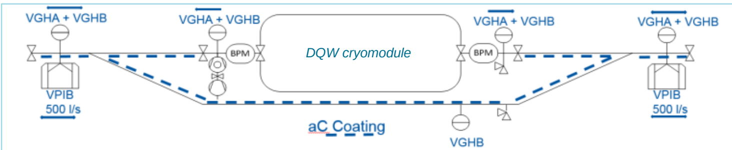
Courtesy M.Amparo – HL-LHC Integration meeting 8 Feb 2019



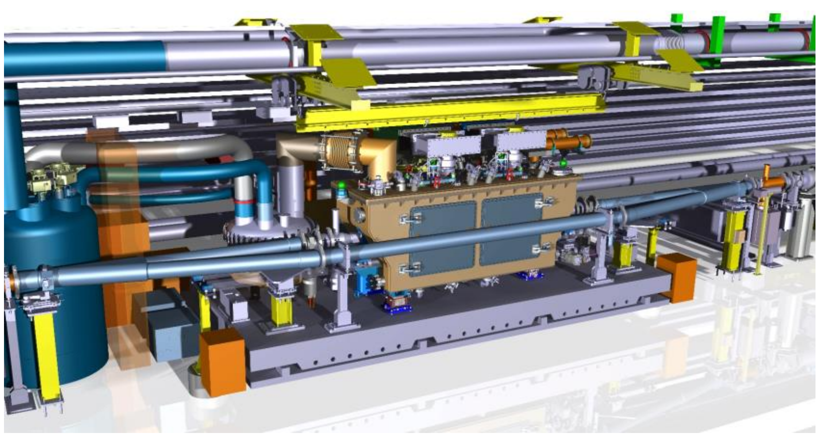


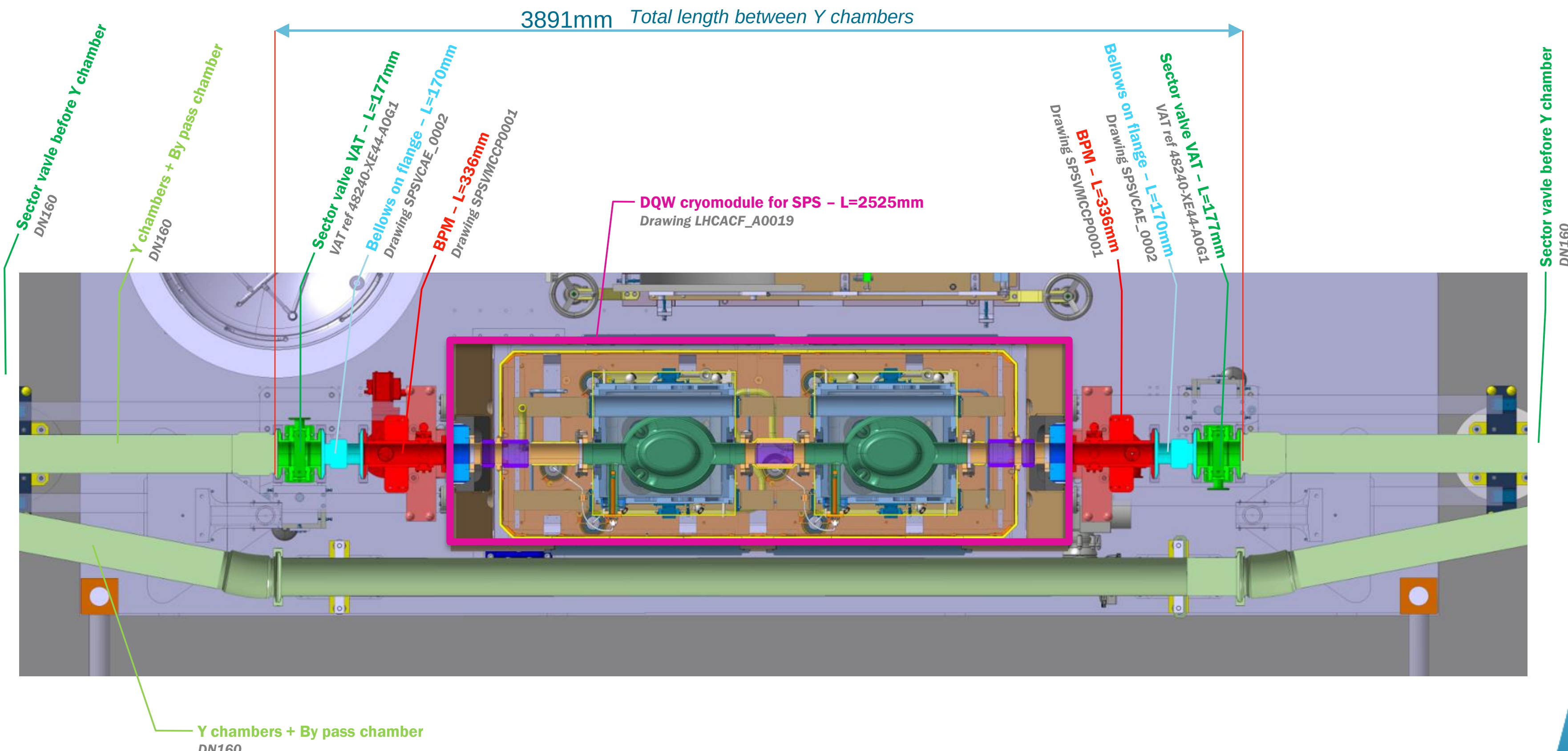
HiLumi HL-LHC PROJECT

SPS test stand integration

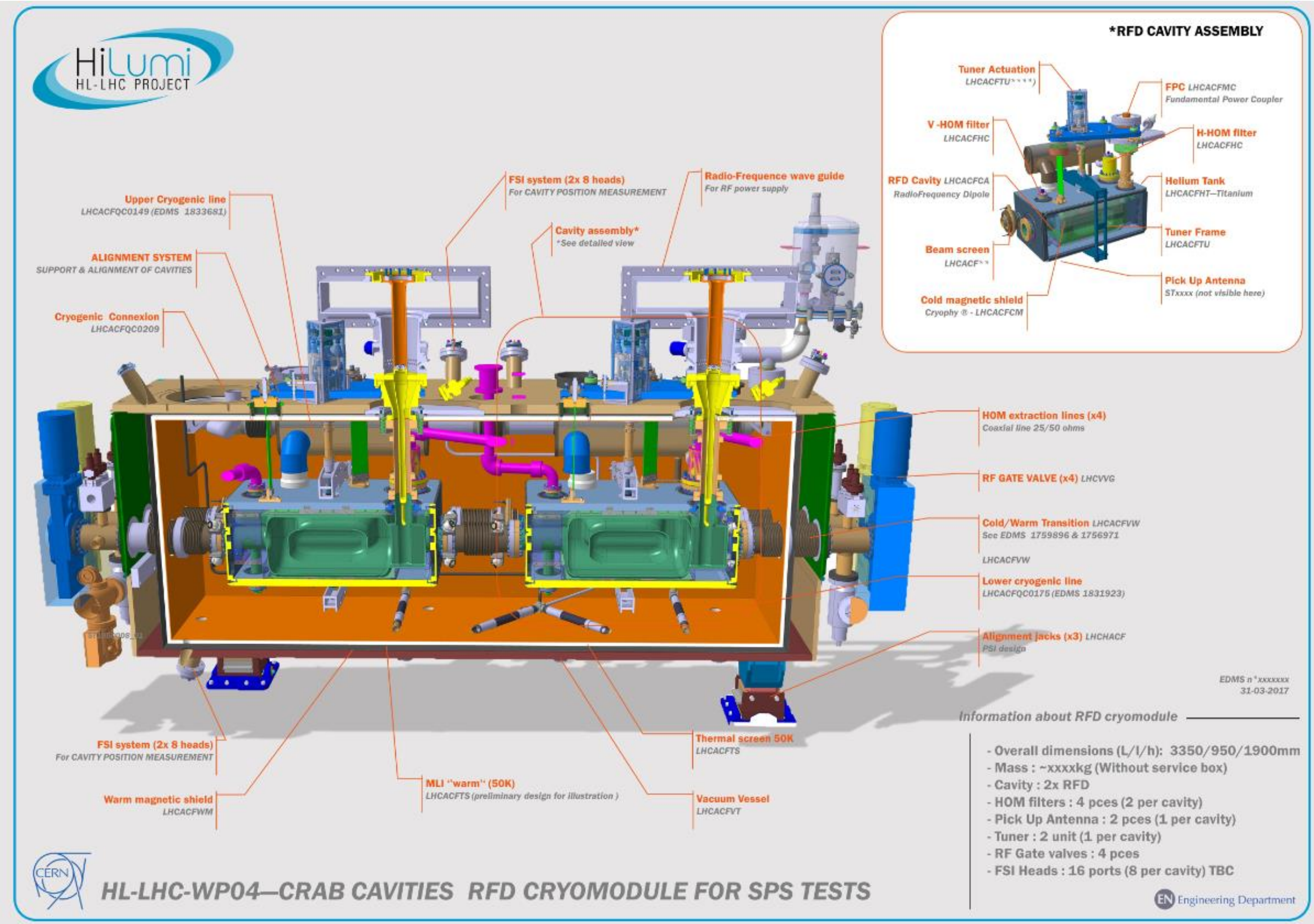


SPS beam vacuum layout for test stand – courtesy Chiara Pasquino TE/VSC

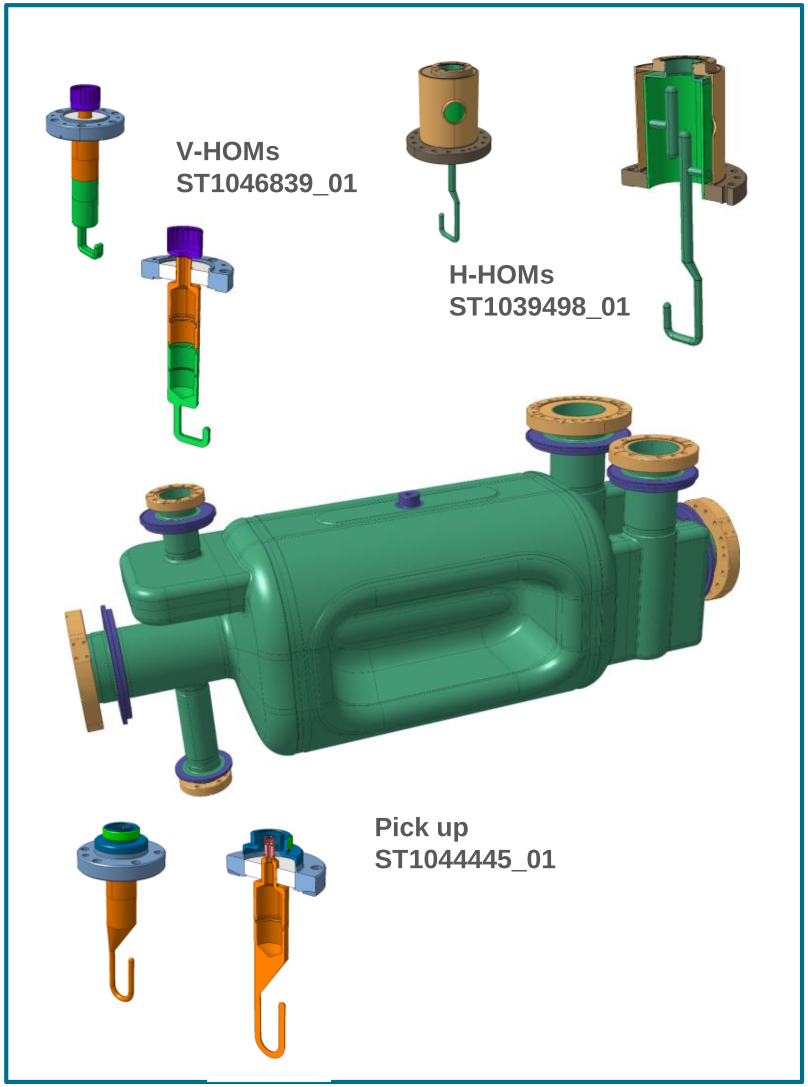


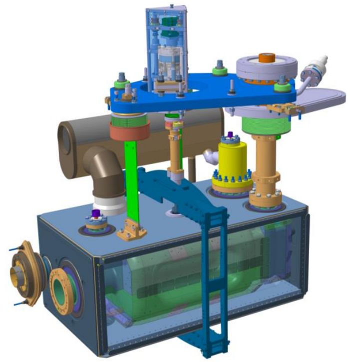


RFD cryomdule



Cavity & RF components





Cavity

- Test of forming on-going
- Design of tooling
- He-tank to be updated

CERN responsible for HOMS, FPC & Pick-Up - E.Montesinos BE/RF

HOMs and Antenna for RFD prototypes, under manufacturing at CERN:

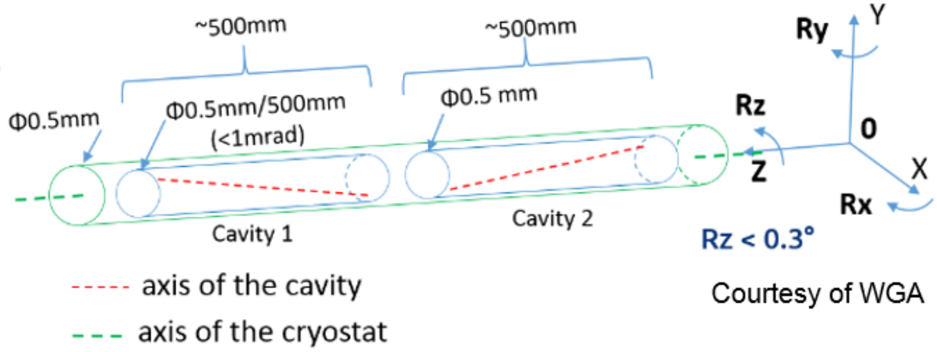
- Mechanical design in progress
- Collaboration BE/RF – CERN workshop (EN-MME)

FPC outer pipe :

- Mechanical design to be adapted
- Definition of the coating process according to the lesson learnt from DQW
- Collaboration EN/MME – BE/RF – TE/VSC

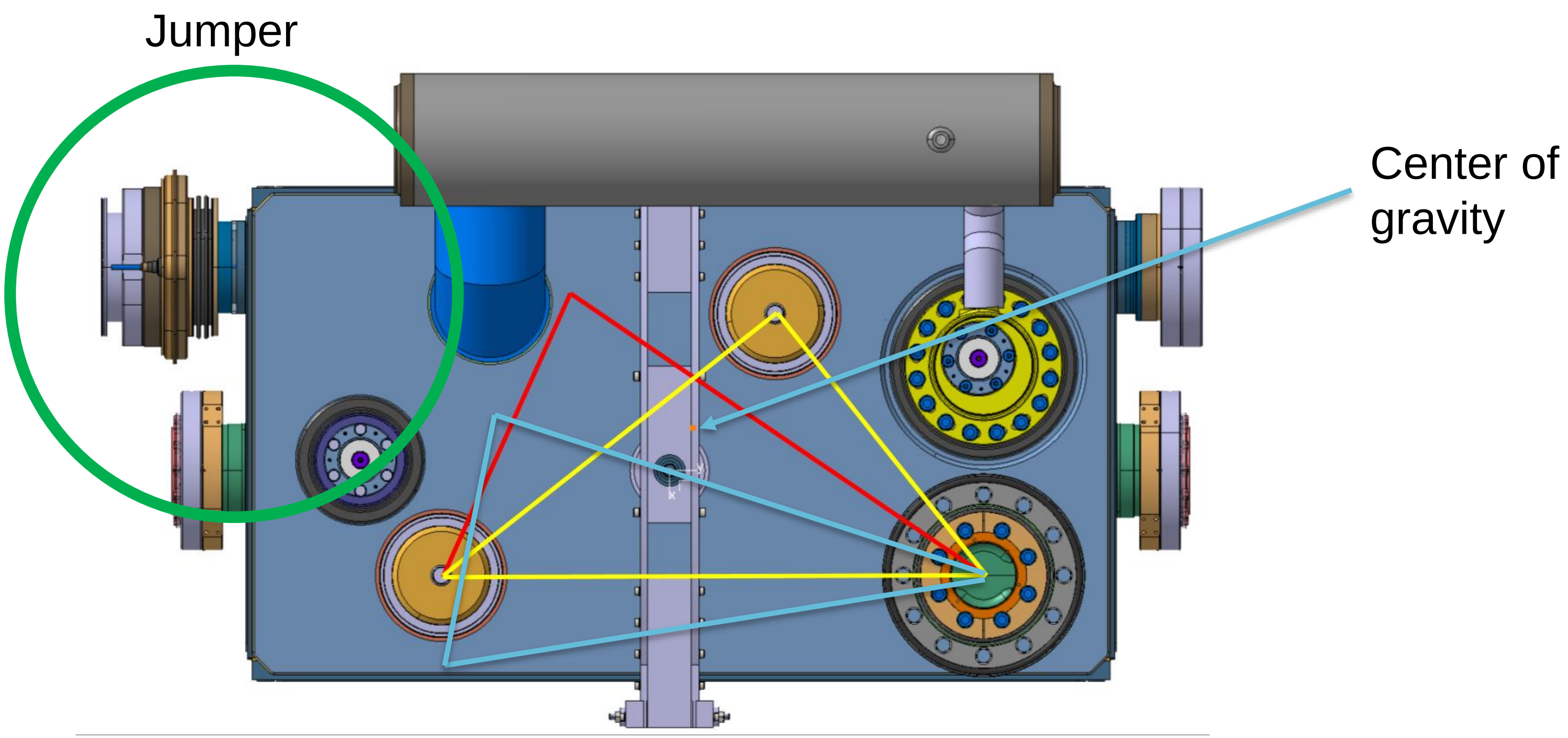
Cavity support and alignment

- Inputs provided by WGA, H. Mainaud & M. Sosin 14/12/2017.
  - Adjustment of the cavities performed at warm temperature, therefore, the position at cold has to be anticipated. Position at warm will be known quite accurately.
    - *Should an error be included due to the shrinkage?*
  - Fiducialization budget (mechanical axis of the flanges of the dressed cavities w.r.t. external targets).
    - ~20µm at warm.
  - Internal monitoring of the position of the mechanical axis of the flanges of the dressed cavities.
    - Rx: < 0.057º = 1 mrad (3 σ) → Ø0.5 mm/500mm.
    - R_z: < 0.3º = 5.2 mrad (2 σ) → ~ *Ø1 mm?*
  - Ground motion budget.
    - *Would be 0.75 mm in radius enough for the ground motion budget?*



- As a first estimation, a budget of ± 1.5 mm is allocated for alignment purposes. → WGA tolerance budget

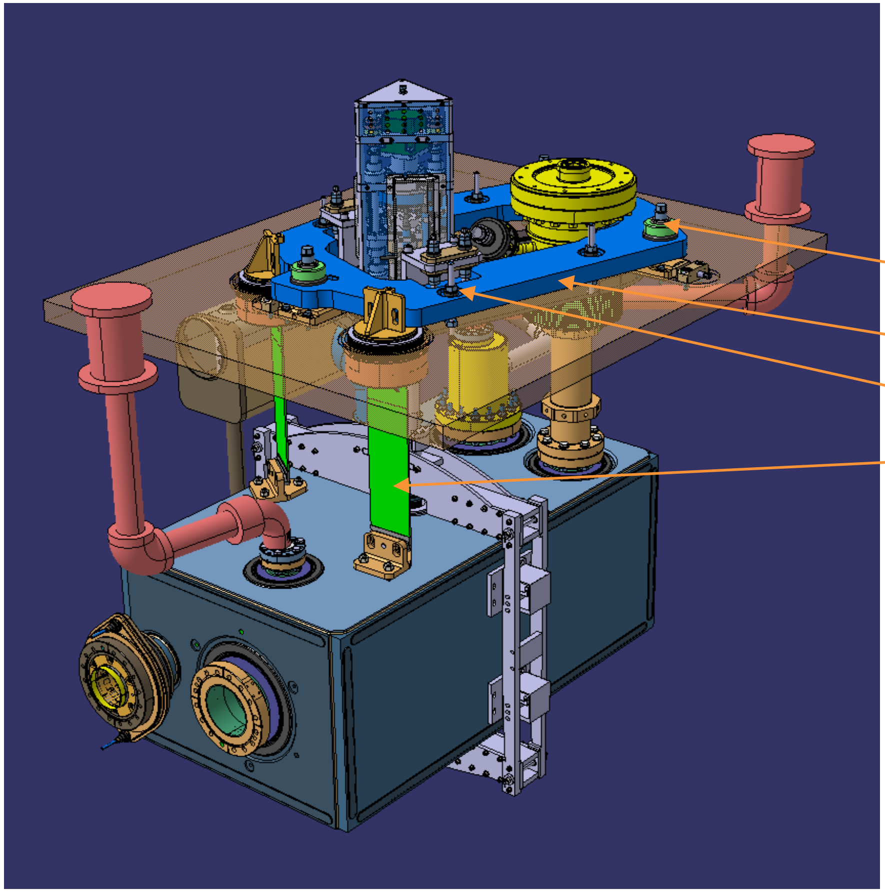
Cavity support



Option 1 blue : Centre of gravity outside of support triangle
Option 2 Yellow : Not symmetrical
Option 3 Red : Need to move biphase connexion (study on going)

Cavity support

- Solution 3 preliminary design : ST1155343
  - Both blades at same distance from FPC
  - Correct accessibility to adjustment
  - Assembly procedure to be checked
  - Tuner accessibility to be optimized

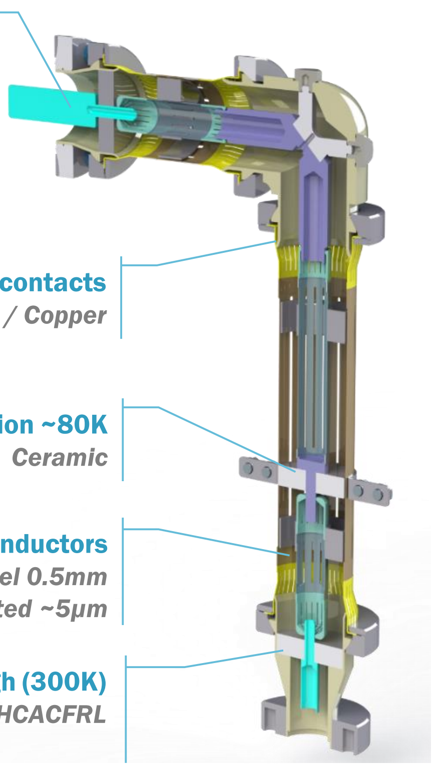


RF COAXIAL LINES

CERN responsible for HOMS, FPC & Pick-Up - E.Montesinos BE/RF

Design constraints :

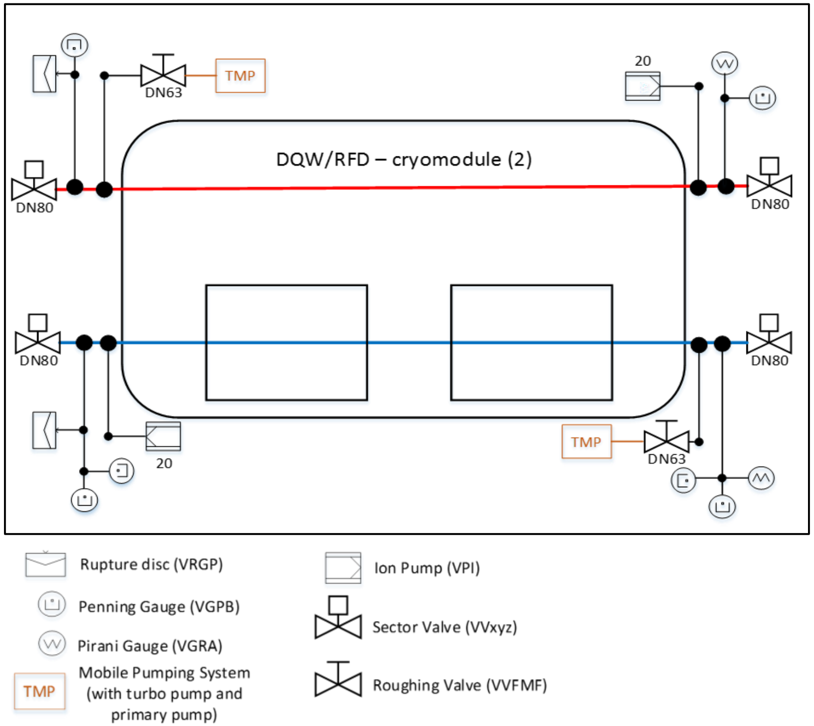
- Installed in insulation vacuum (not cooled by convection)
- RF power to be extracted
- Minimize thermal load to 2K bath
- Alignment and thermal contraction compensation
- Limited room for installation inside the cryomodule

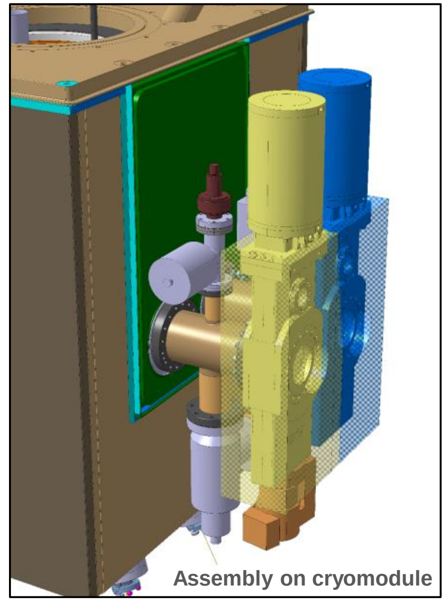


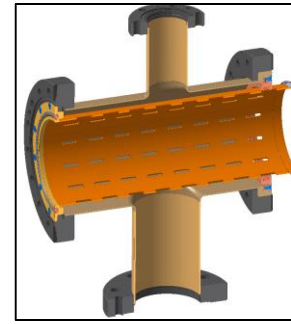
Additionnal information

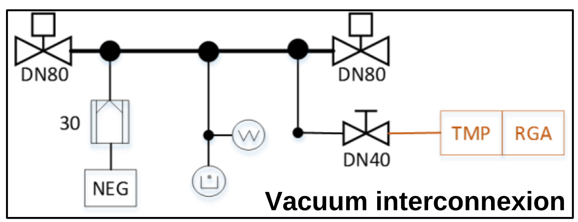
- 2 V-HOMS coaxial lines
- 2 H-HOMS coaxial lines
- 2 Antennas coaxial lines
- Size and design standardized for all lines
  - S.Steel with copper coating
  - Extremities compatible with standard connector
  - Shapal ring for thermalisation of inner line
  - Alumina for vacuum feedthrough

Beam Vacuum instrumentation



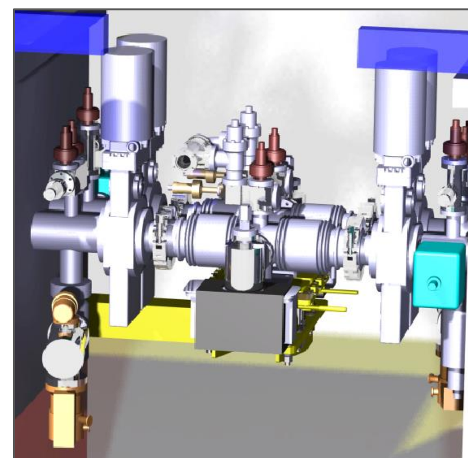

Assembly on cryomodule


Extremity chamber

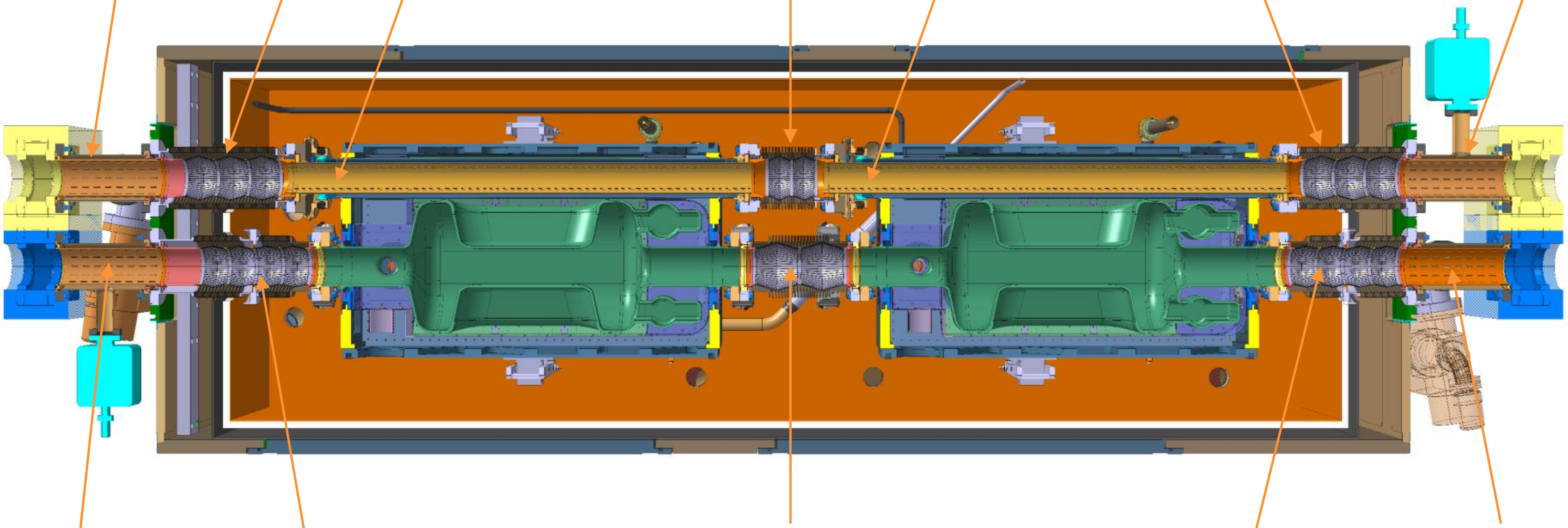


Vacuum interconnexion

Courtesy R. Tavares Rego (TE/VSC) EDMS 1864637


Interconnexion LHC

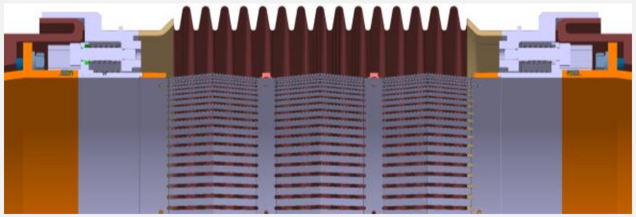
Cryomdule beam section

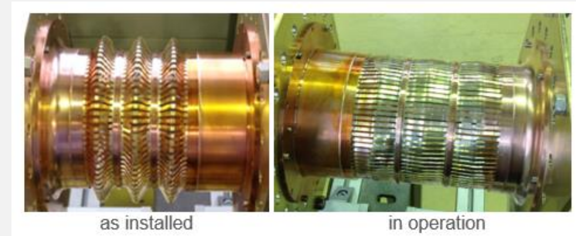


RF screen for bellows

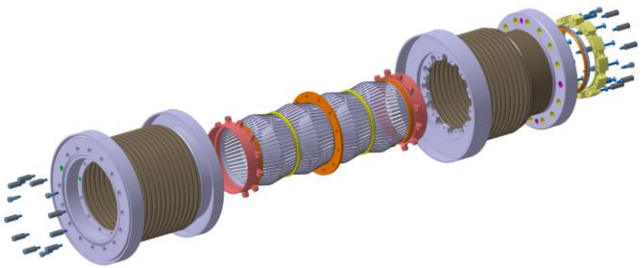
Copper Beryllium deformable RF fingers:

- Circular aperture
- C17410
- 0.1 mm thick, 3 mm width, gap: 1.4 mm
- 3 convolutions





Extracted from presentation of C.Garion
33rd HL-LHC TCC– 13 July 2017



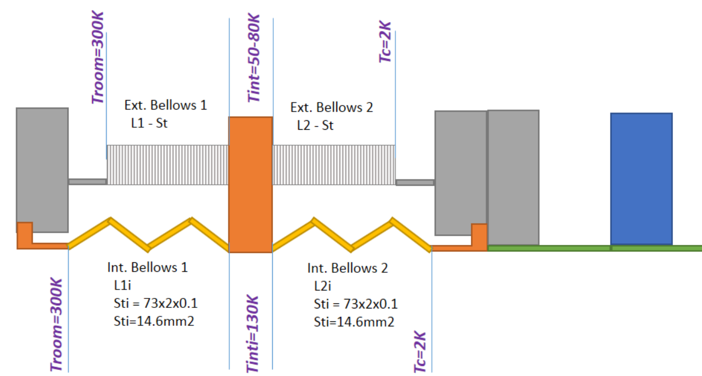
Rough estimate of thermal loads on 2K and thermal screen

With thermalisation at 50% of total length

T° thermal intercept = 80K ext / 130K finger

$Q_{80K} := Q_{screen} + Q_{screeni} = 1.982\ W$

$Q_{2K} := Q_{bath} + Q_{bathi} = 0.51\ W$

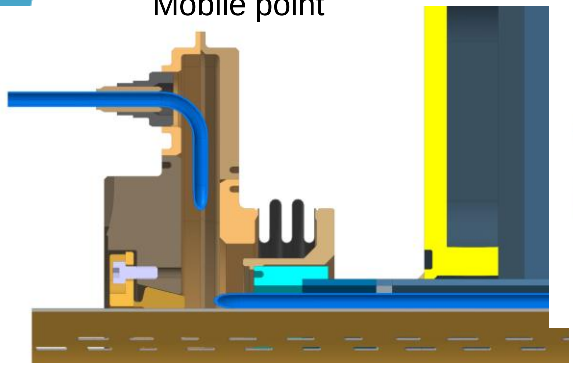


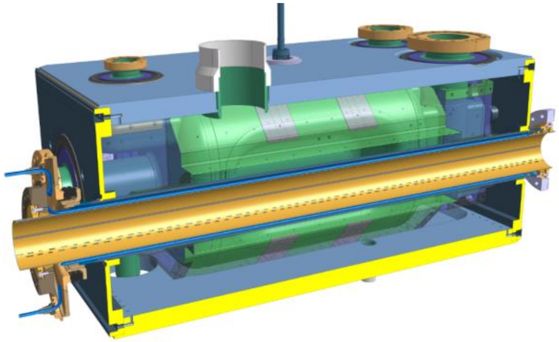
Without thermalisation

$Q_{2K} := Q_{bathe} + Q_{bathi} = 1.112\ W$

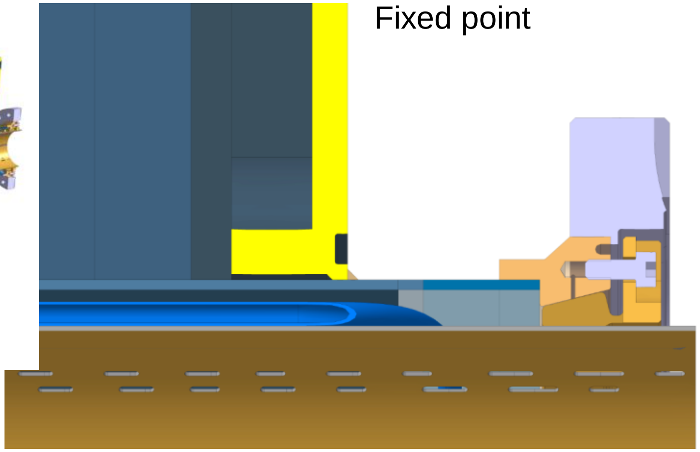
Beam screen optimization

Mobile point





Fixed point

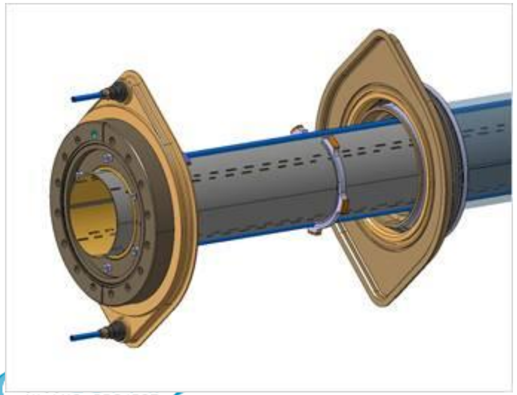


3D model: ST1107356_01

Datas :

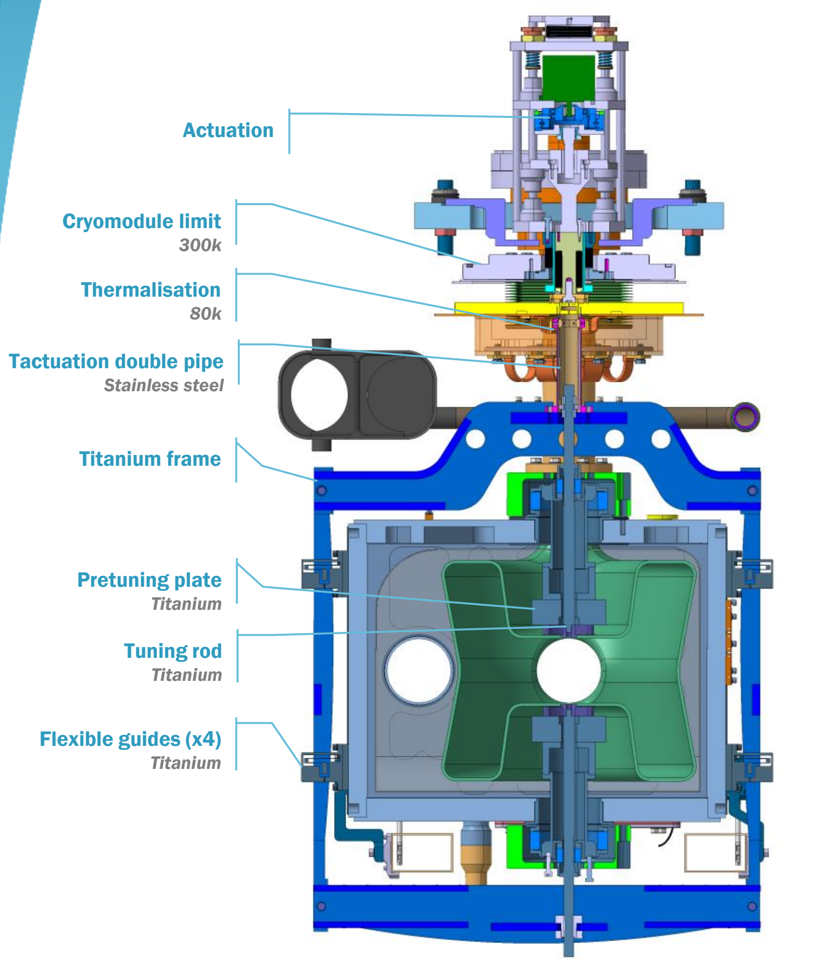
Stainless steel screen with «random» holes for pumping
Copper layer on the inner surface (th. 0.075mm)
Ø4.76mm cooling pipe welded on screen (He gaz @ 20K)
1 bellows for differential contraction

Insertion of beam screen in cold bore

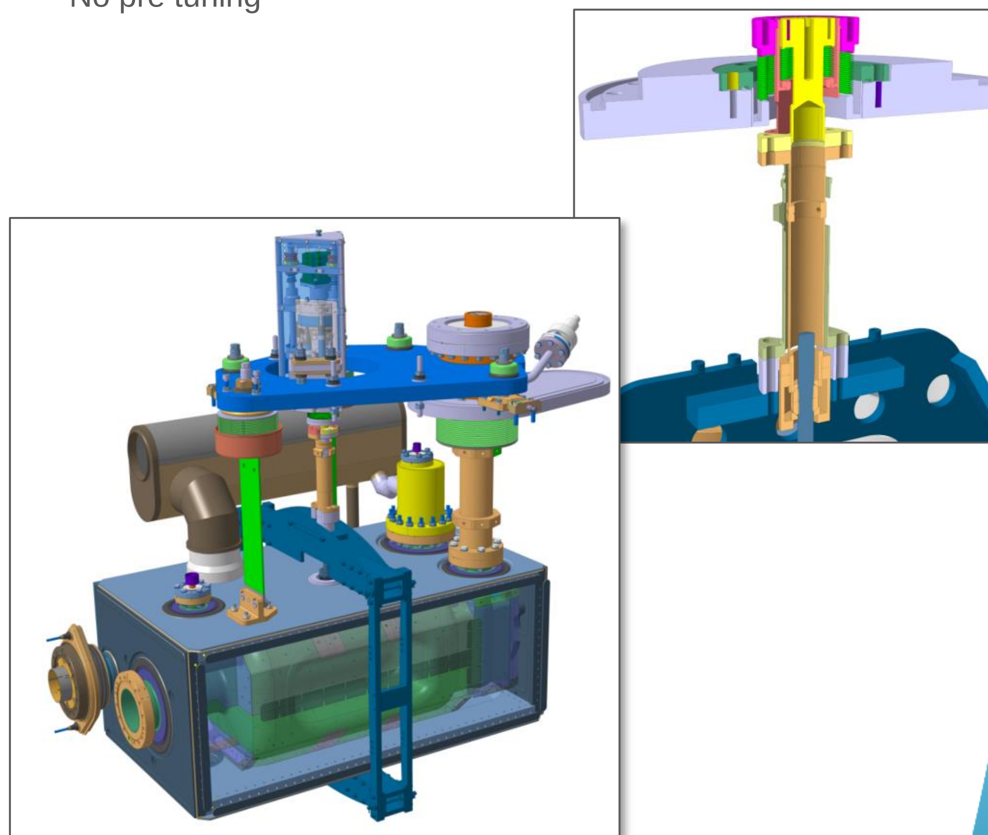


Tuning system

- Adaptation of DQW design
- Modification following lessons learned with DQW
- No pre tuning



DQW design for illustration

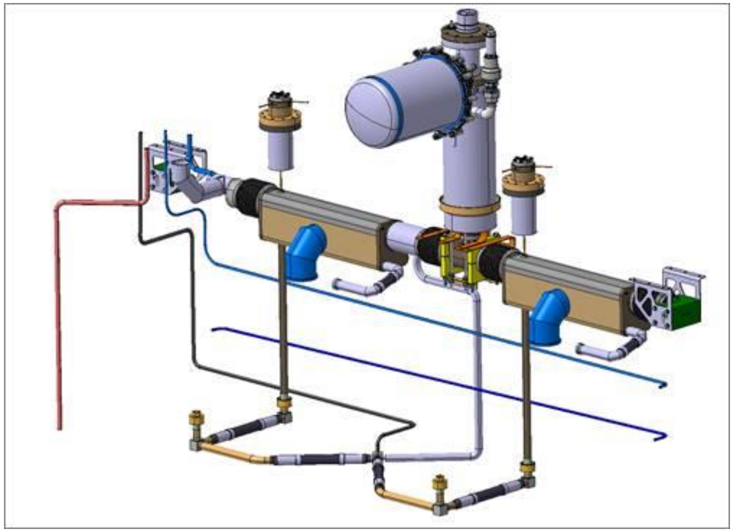


RFD design (on going)

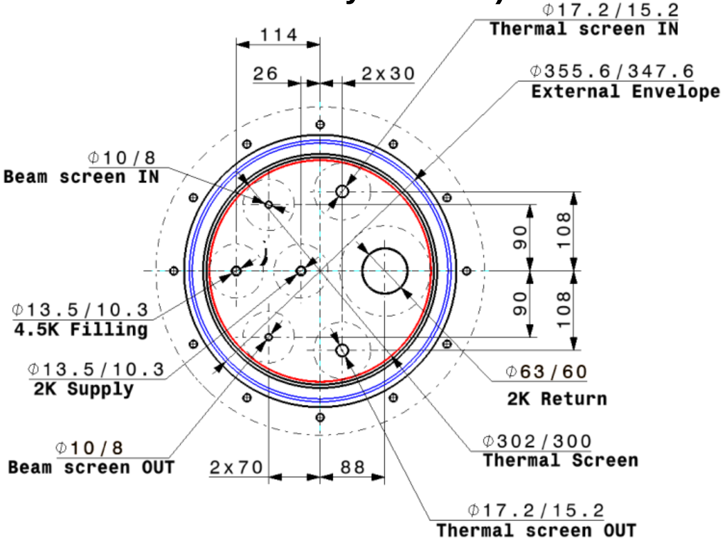
Cryogenic

Detail study on-going

Cryogenic safety valve integration



Symmetrical jumper interface
(allows the rotation of cryomodule)



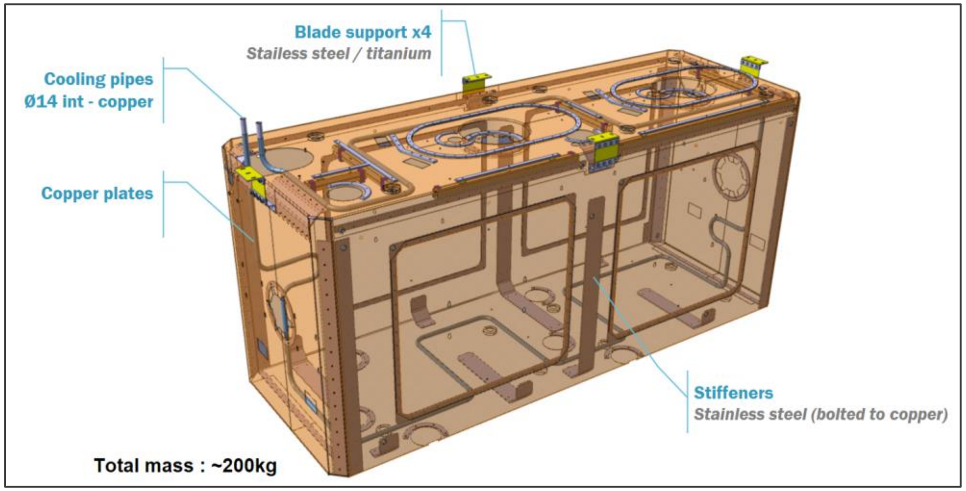
LHCACFQC0209 : jumper interface LHC

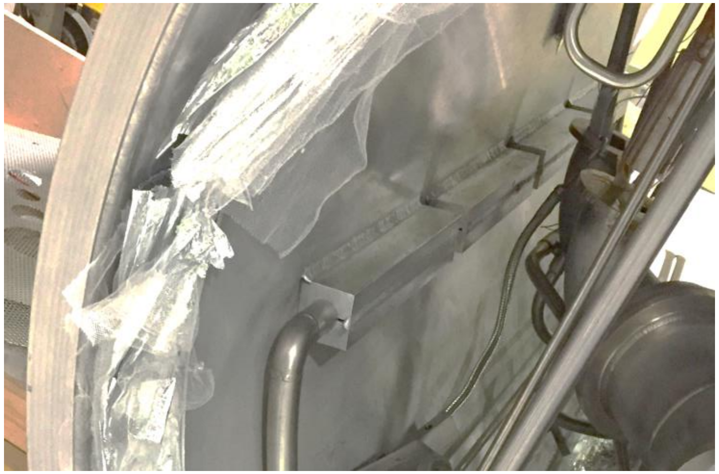
Compensator for lower cryoline + HOMs : 4 + 2
- **Dimension defined**
- **Same compensator everywhere**
- **Material for welded collars 316LN**
- **Material for external housing TBD**
- **Max pressure : 2.1 bar**
- **Maximum latteral displacement**
- **->launch supplier consultation**

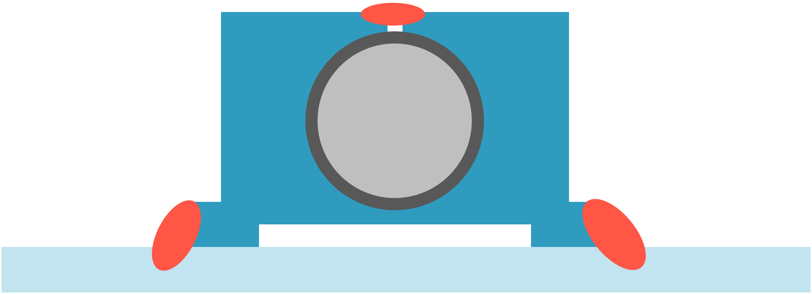
Bellow for Biphase (DN100 and DN63) : 3x DN100 + 2x DN63
Bellow for Level gauges (DN10) : 4

Thermal screen (STFC/UKRI)

- **DQW design :**
  - Copper plates th. 3mm
  - Copper pipes brazed to plates
  - Operating pressure 18 bars
  - Transition copper/s.steel for final welds
- **RFD/DQW design for series**:
  - Aluminium plates th. 2/3mm
  - S.steel pipes clamped to plates
  - Operating pressure 25 bars

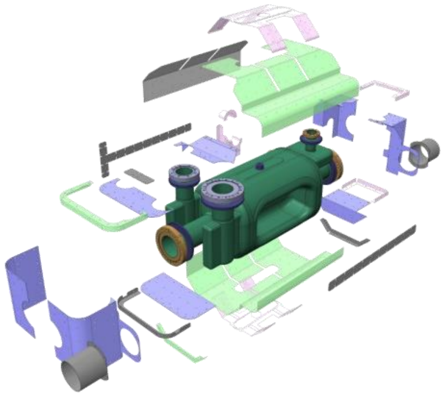




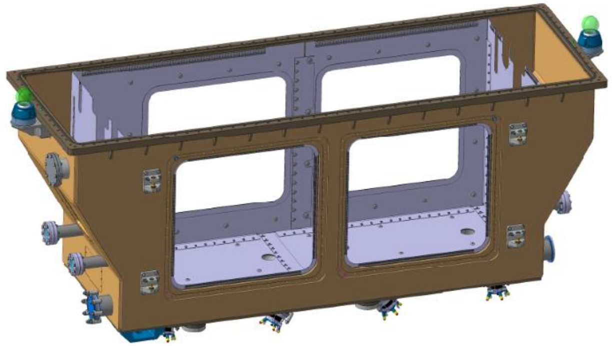


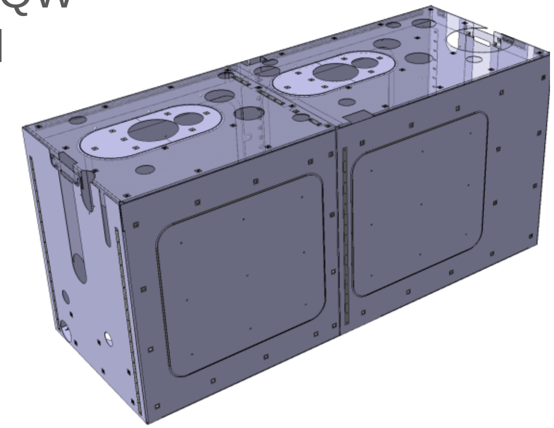
Magnetic Shield (STFC)

- **Cold magnetic shield (2K):**
  - Modification of design on going
  - Assembly sequence to be checked
  - Material : Cryophy



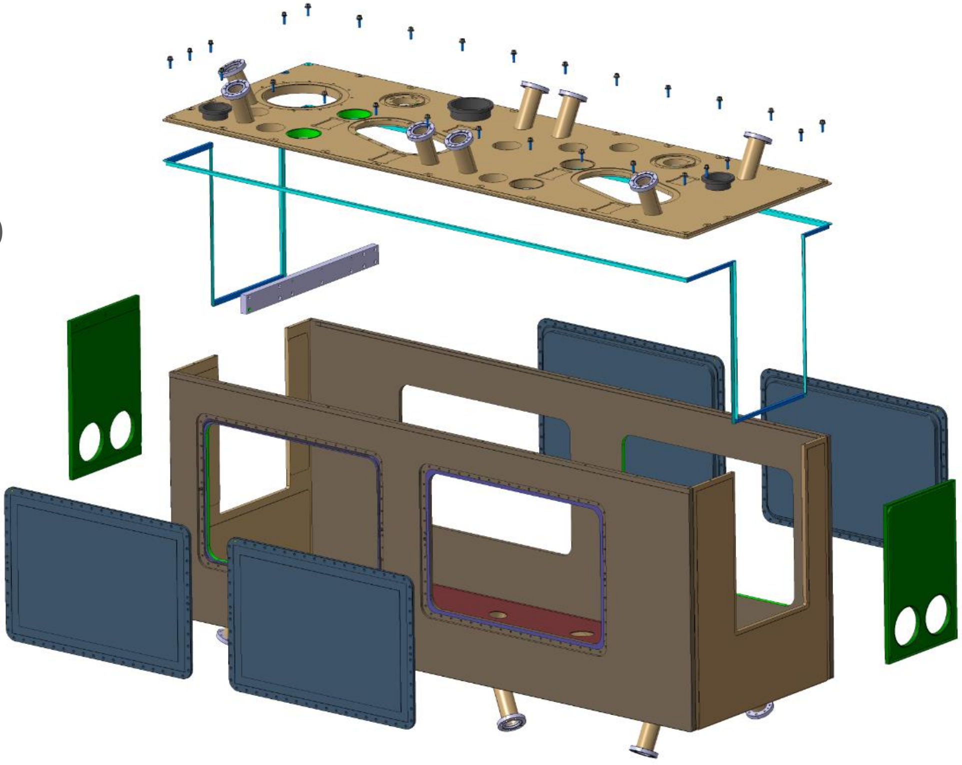
- **Warm magnetic shield (300K):**
  - Design to be done
  - Adaptation from DQW
  - Material : Mumetal



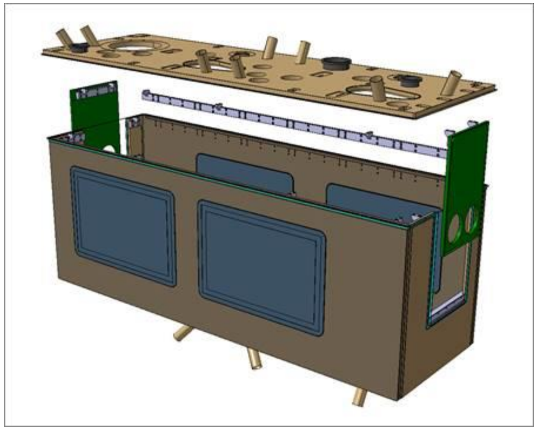


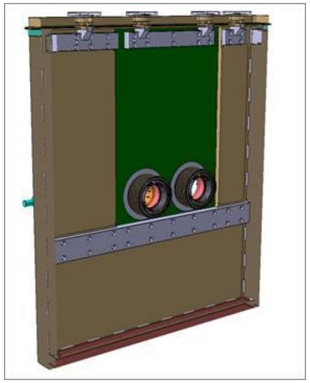
Vacuum tank

- **Outer vacuum chamber**
  - Keep the same assembly principle (top plate/lower vessel)
  - Accessibility to the inner component
  - Material : Stainless steel



Reinforcement under study

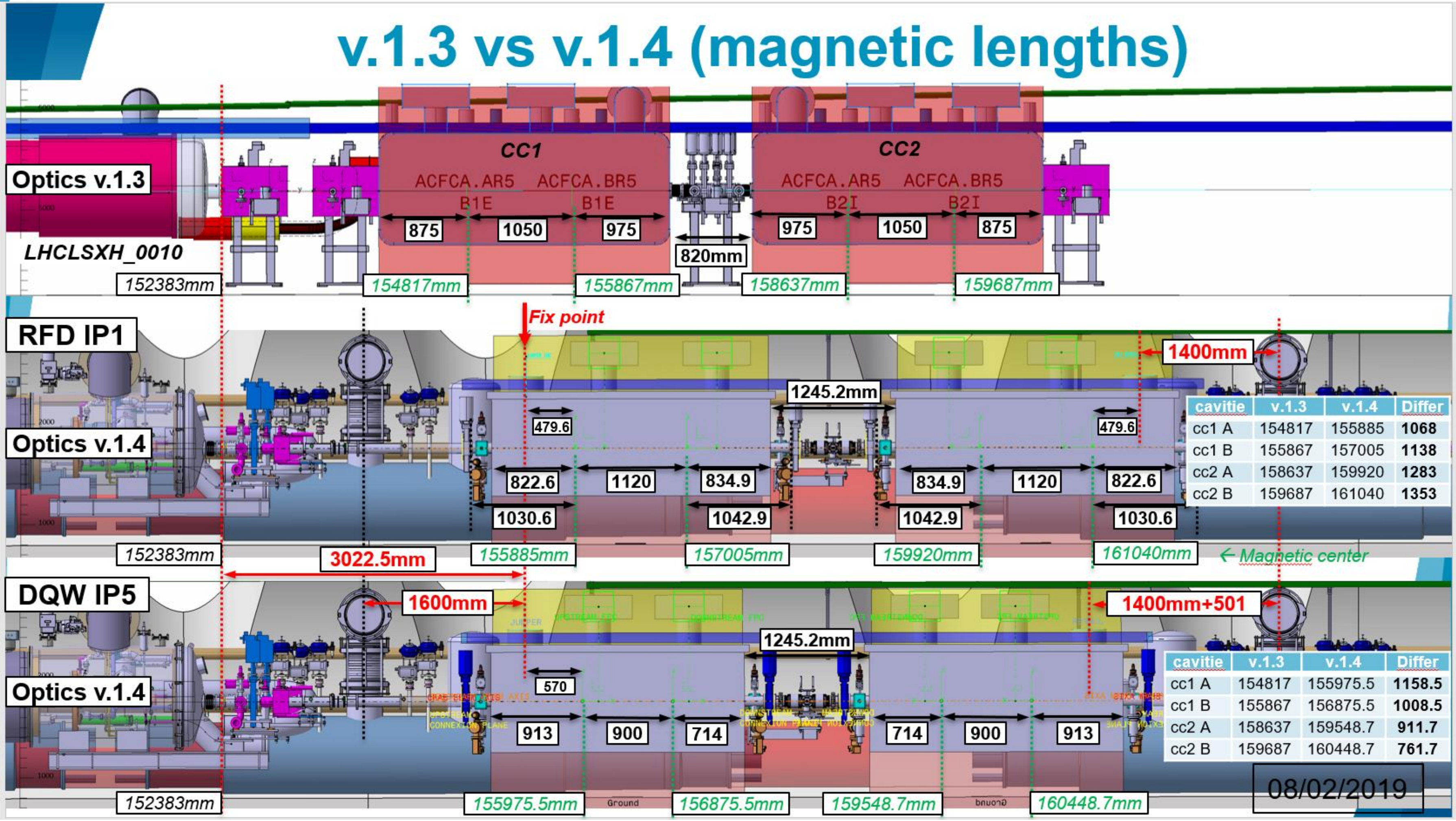




Several version studied
This version minimize the quantity of weld on site while keeping a great accessibility to every internal component during assembly

End

Integration LHC



cavitie	v.1.3	v.1.4	Differ
cc1 A	154817	155885	1068
cc1 B	155867	157005	1138
cc2 A	158637	159920	1283
cc2 B	159687	161040	1353

cavitie	v.1.3	v.1.4	Differ
cc1 A	154817	155975.5	1158.5
cc1 B	155867	156875.5	1008.5
cc2 A	158637	159548.7	911.7
cc2 B	159687	160448.7	761.7

Courtesy M.Amparo – HL-LHC Integration meeting 8 Feb 2019