EDMS#: 2219953

Vacuum: Full Remote Alignment System

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Review of HL-LHC Alignment and Internal Metrology (WP15.4)
26.08.2019

Outline

- Baseline and requirements
- Vacuum components to be aligned
  - D1 to TAXN (drift tubes with supports)
  - TAXN to D2
  - D2 to Crab Cavities
  - Q4-Q5 Magnets

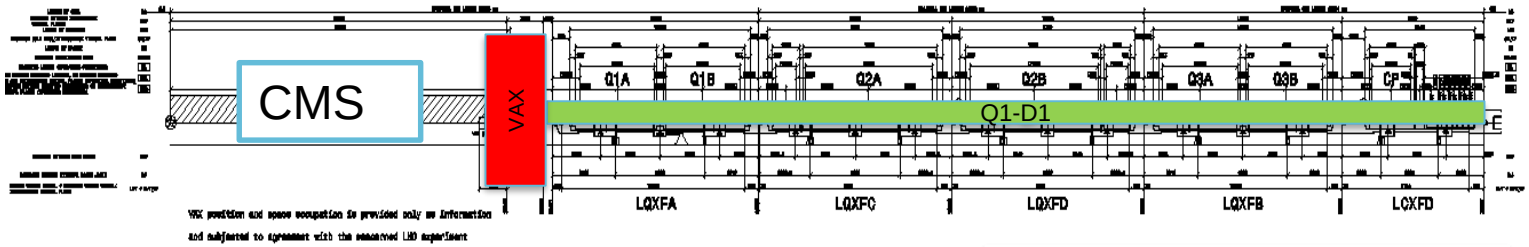
  FRAS
- Clearance for the VABs at D2, Q4 and Q5
- Readiness and risks
- Conclusions

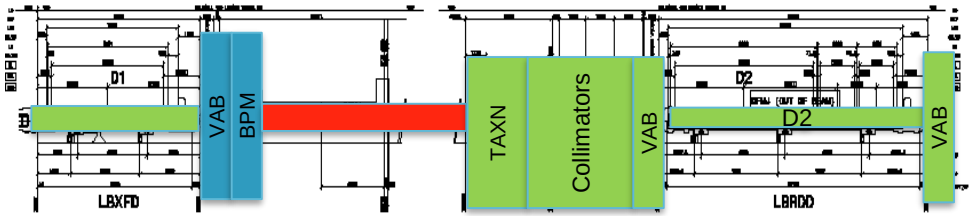
Documentation:
P. Fessia, H. Mainaud Durand, "Full Remote Alignment Specification". EDMS 2166298 ➔ collaboration WP2, 12 and 15.4
J. Hansen and R. Rego, "Vacuum FRAS functional specification", 12/04/2019, EDMS 2113939

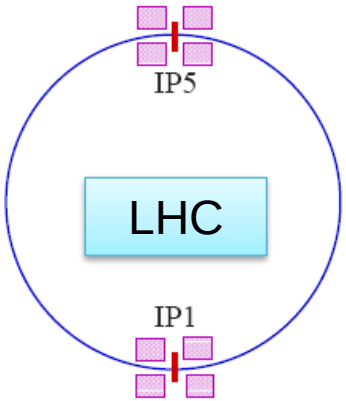
Baseline for alignment of IP1 and IP5

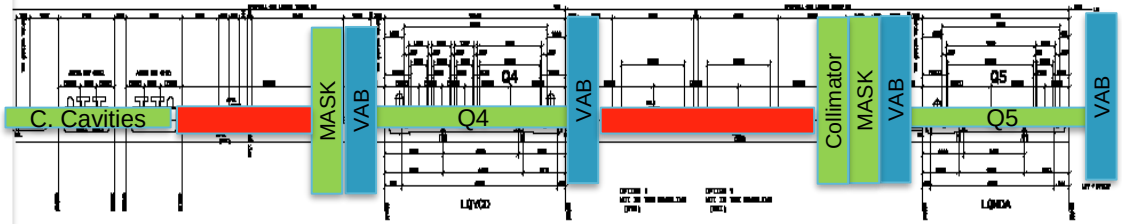
Layout :
IP5 Right

-IP5 left and IP1 will have the same alignment configuration









Remote aligned

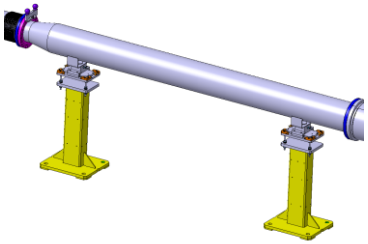
Manual aligned by Survey

Manual aligned by TE/VSC or Survey

Vacuum components to be aligned

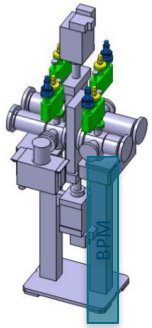
Case 1: Components to be aligned by Survey

Manually aligned:
(support only or with vacuum component)



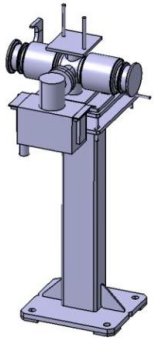
Transition Vacuum Chambers with supports

VCT



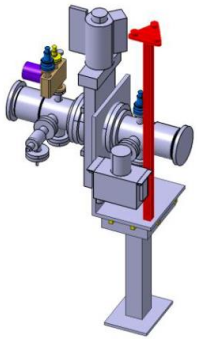
Double vacuum assembly

VAB



Double vacuum module

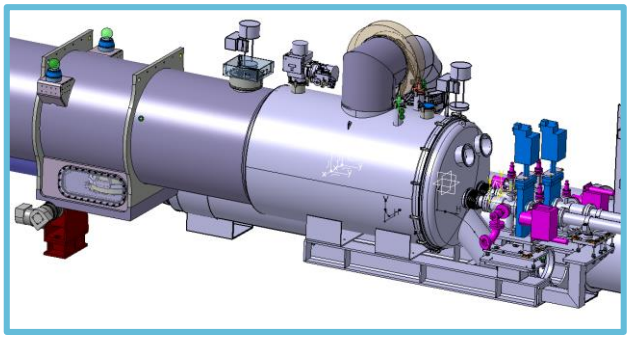
VM



Single vacuum assembly

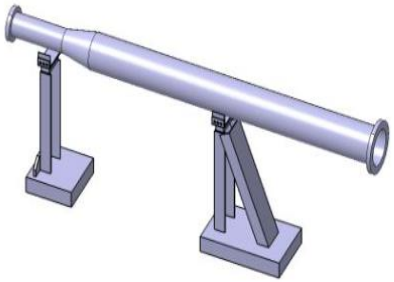
VAB

Remote aligned together with magnet:

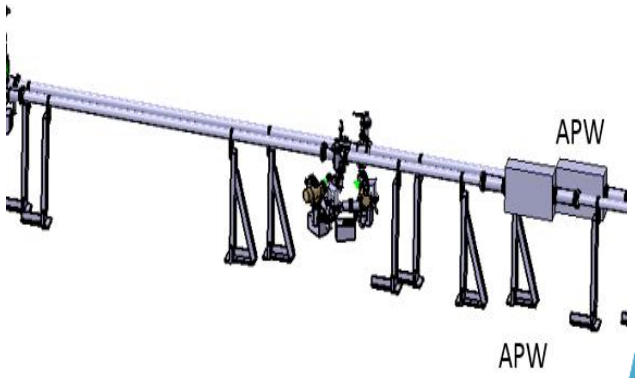


VAB Double valve module

Case 2: Components aligned by TE/VSC



Transition Vacuum Chambers with supports



Vacuum Chambers with supports

Requirements

- Beam size was provided by R. de Maria in May 2018 (*meeting between WP2, 12 and 15.4 in sept 2019 for final documentation*).
- The remote alignment transversal stroke for all components is fixed to +/- 2.5 mm.
  This value needs to be subtracted from the aperture when fixed components are considered. These fixed components are the ones manually aligned either by TE/VSC or SU.
- Mechanical Aperture:
  - Apertures **in radius** including mechanical tolerances.
  - Not including alignment tolerances.
  - Apertures:

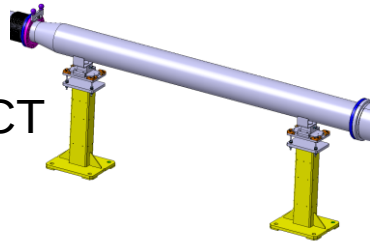
Component	Inner radius [mm]	Aperture [mm]
VM (Pumping module)	31.5	30.575
	40	39.075
	45	44.075
VVG (Sector valve)	50	48
	31.5	31.100

- Alignment tolerances for first alignment:
  - Manual aligned by TE/VSC (F): +/- 2 mm;
  - Manual (S) or remotely (R) aligned by SU: +/- 0.5 mm.

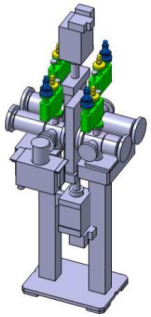
Example:
VM ID63 when the alignment is:
- F: Aperture = 28.575 mm;
- S/R: Aperture = 30.075 mm.

Alignment approach for vacuum components

VCT

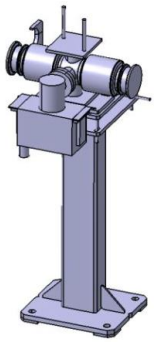


VAB



Double vacuum assembly

VM

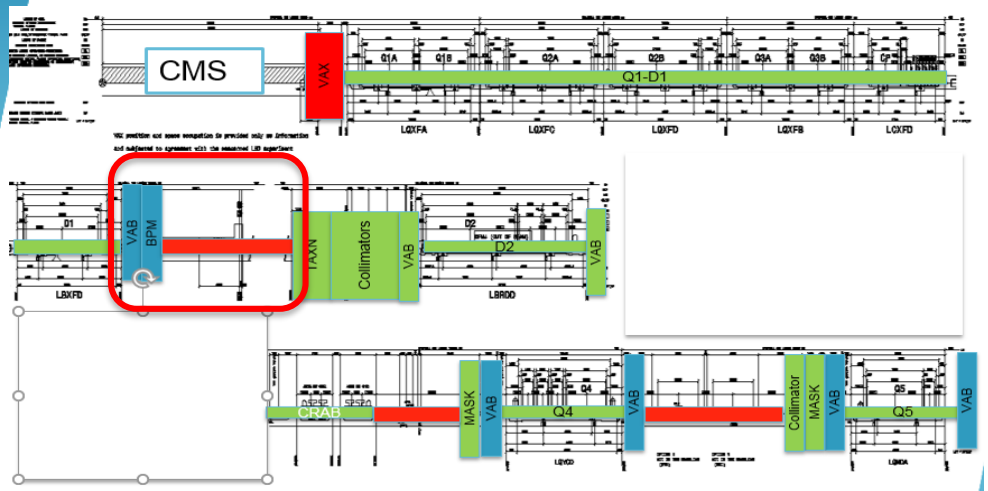


Double vacuum module

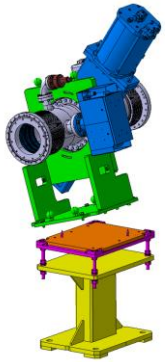
- **Assembly on surface:**
  - Fiducialisation of each vacuum component.
- **Installation in the tunnel:**
  - Alignment of each vacuum component with the support (*TE/VSC will perform the adjustment of the equipment and SU will pilot the alignment of the equipment*)
- **During first year of operation:**
  - No realignment is foreseen.
- **During later operation/During TS, YETS, LS.**
  - No need for realignment (sufficient aperture);
  - The supports will have a quick connect plate:
    - Alignment required if floor support has to be removed.
    - No realignment required if VCT, VAB or VM is removed and reinstalled.

D1 to TAXN

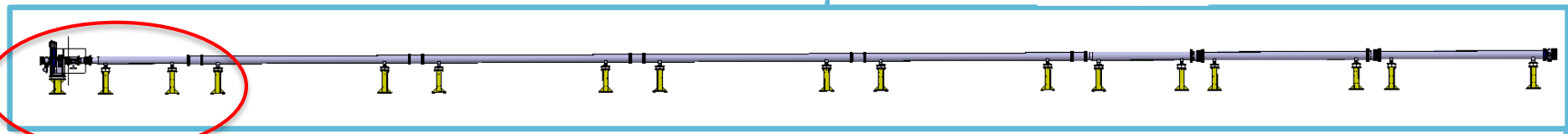
IP5 Right

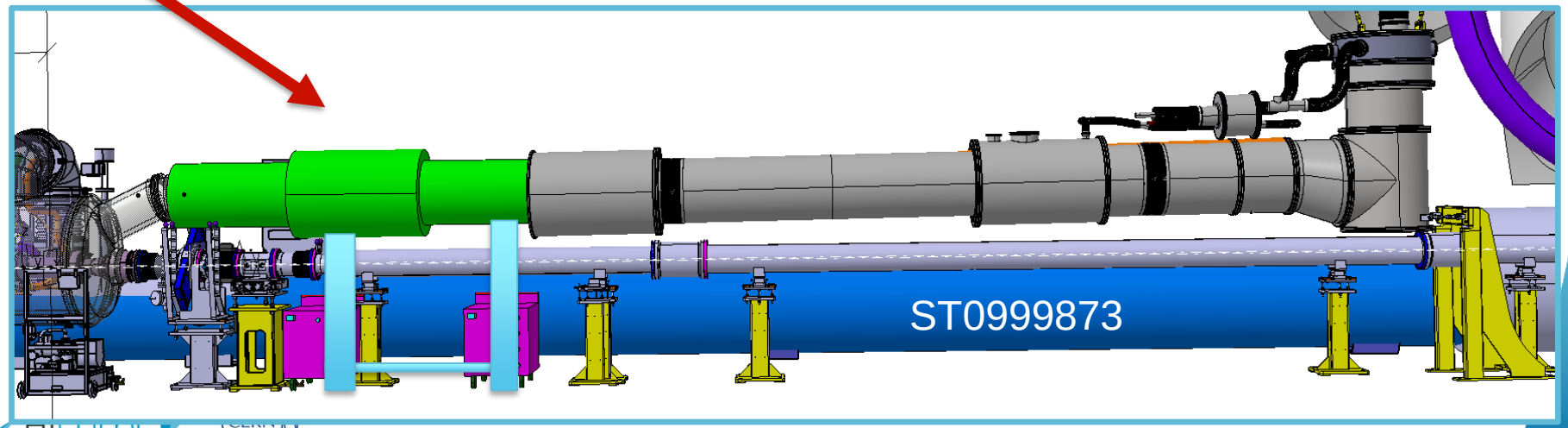


All items between D1 and TAXN will be manually aligned once at installation by Survey



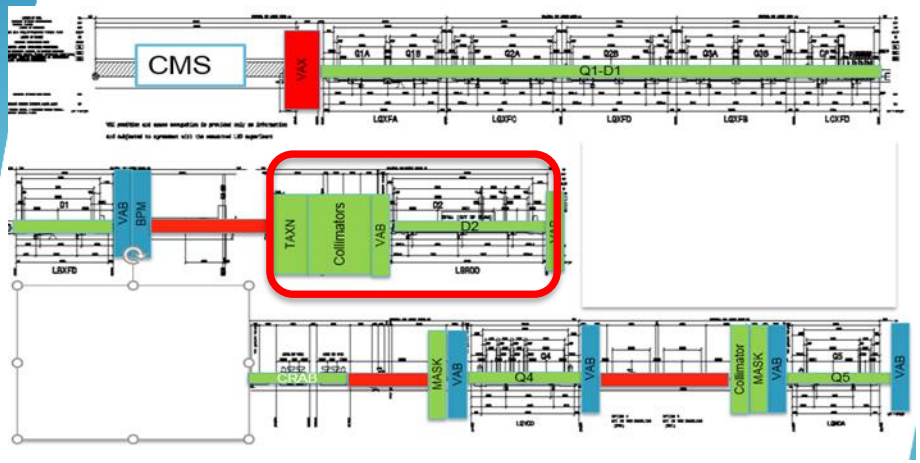
Plug-in interface



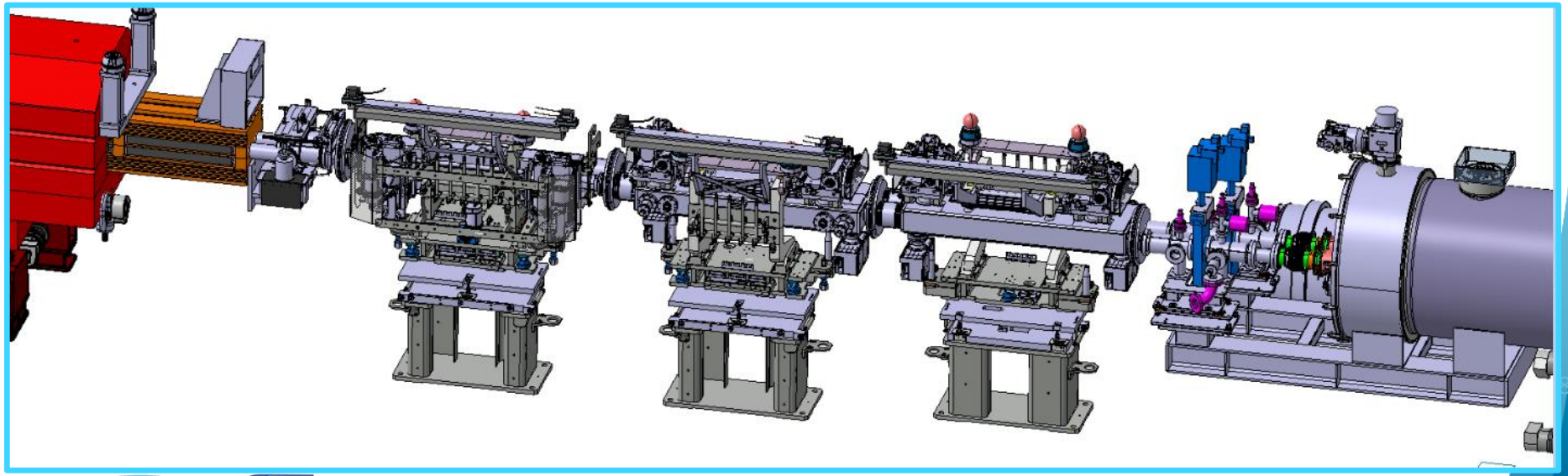


TAXN to D2

IP5 Right

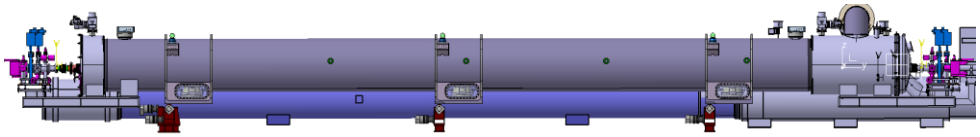


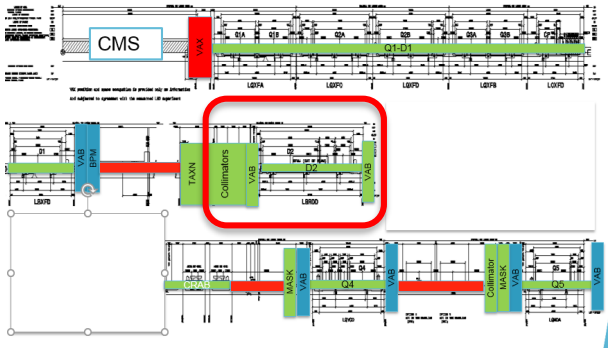
- All items between TAXN and D2 will be remotely aligned
- All pumps, gauges and VVs are remotely aligned as:
  - Incorporated on the collimators;
  - Fixed to the TAXN;
  - Fixed to D2.

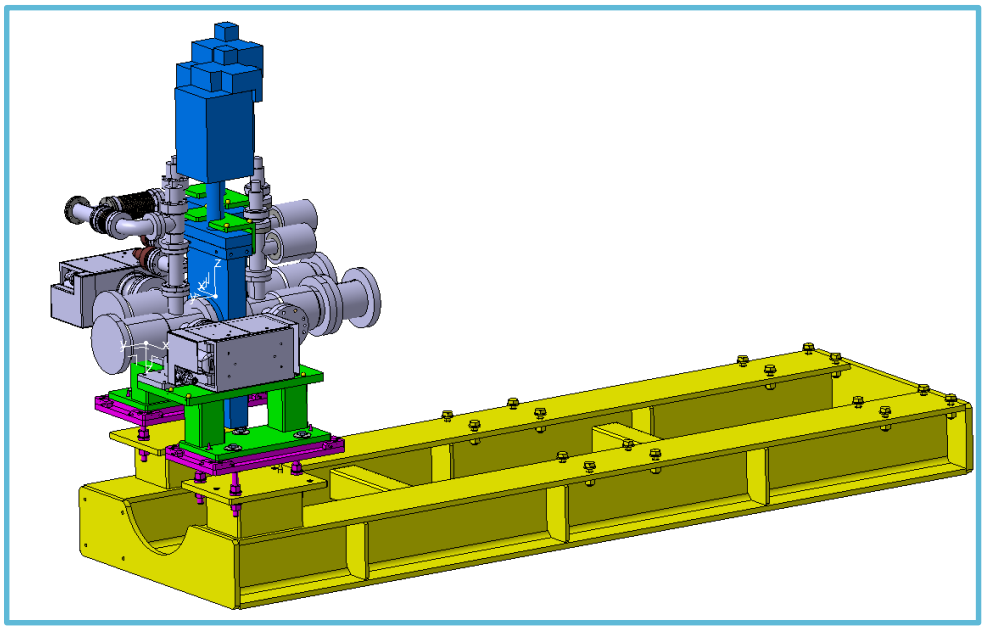


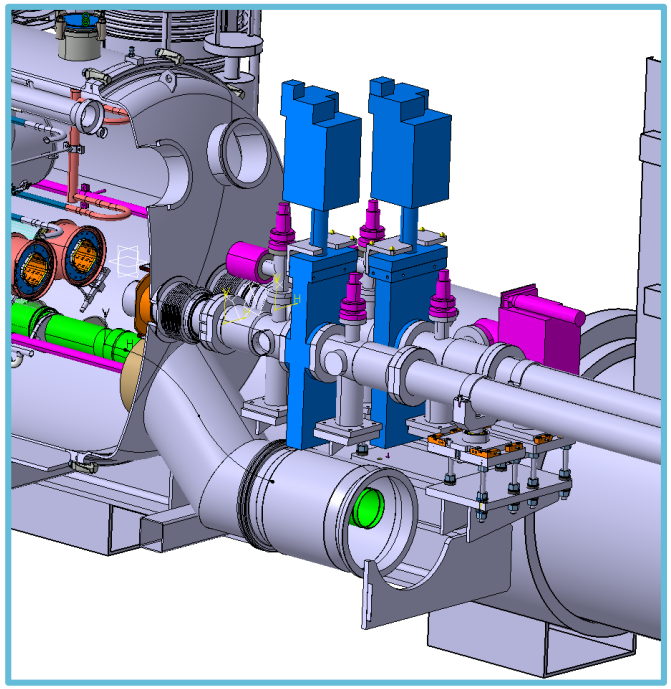
D2 Frame and valve support

- Vacuum support:
  - Fixed to D2 magnet
  - Remote aligned with D2
  - ECR for the sector valves fixed to D2 in preparation.
- Frame will support:
  - VABs (sector valves, bellows and pumping ports)
  - The vacuum chambers on the crab cavity side.
- Sector valve support:
  - Can be installed after the assembly of the link;
  - Will be installed and aligned separately on the frame;
  - Each valve support has targets (“mires”) and will be aligned by SU.

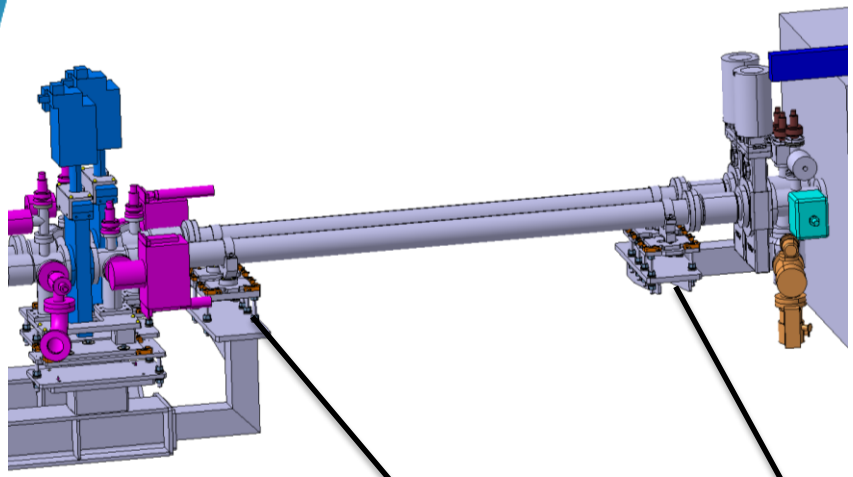






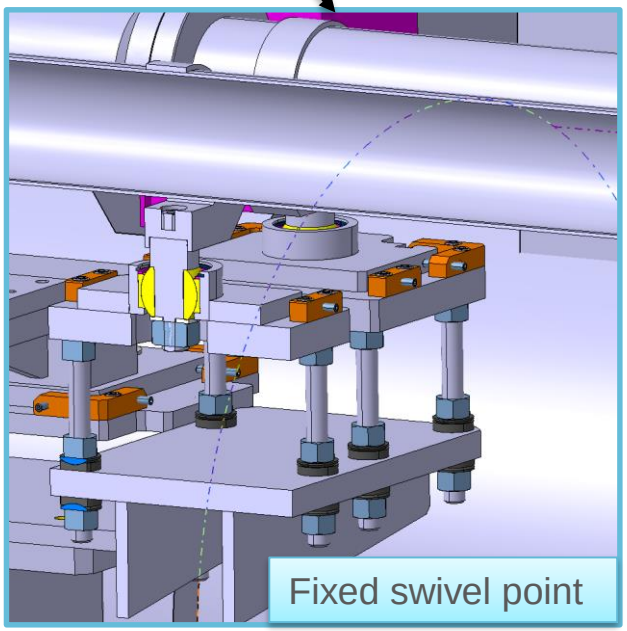


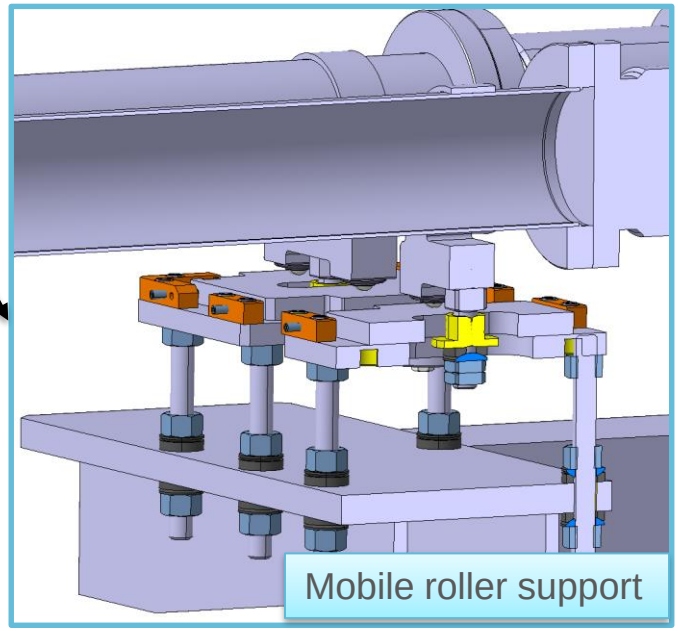
D2 to Crab Cavities



Vacuum chambers supported by the crab cavities and D2 frame;

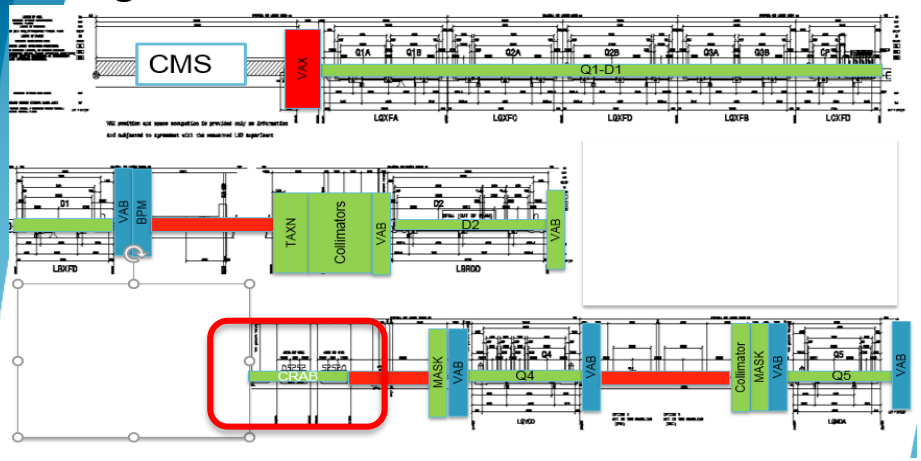
- D2's support of the VCs:
  - Fixed swivel point.
- CCs cryostat's support of the VCs:
  - Roller (to compensate for alignment tolerances and bakeout expansions).





Crab Cavities

IP5 Right

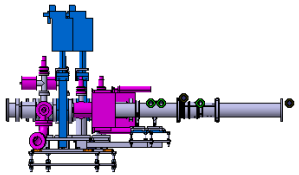


The distance between the cavities and D2 and between the 2 cavities are the same for both versions (IP1 and IP5).

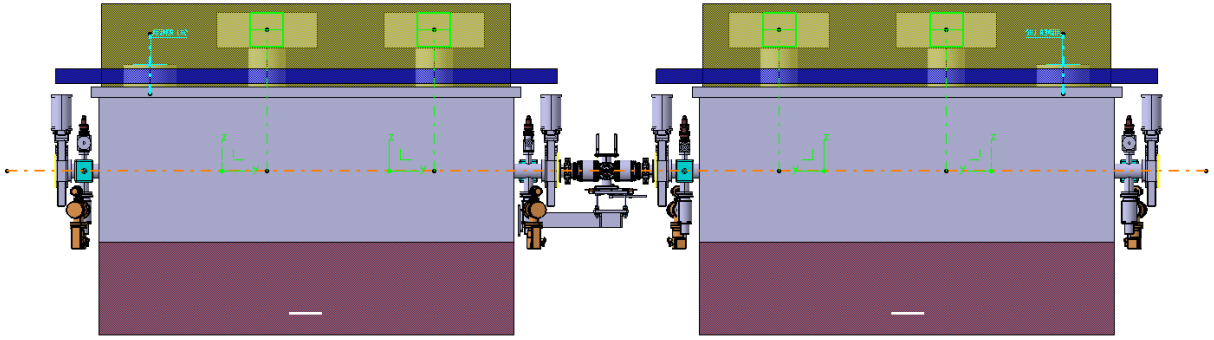
The DN80CF sector valve modules with pumps will be fitted in clean room directly on the crab cavity ➔ no alignment required

RFD

D2

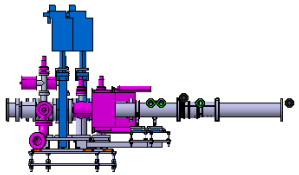


RFD Crab Cavities
LHC – WP15 Integration
(ST1088593_01)

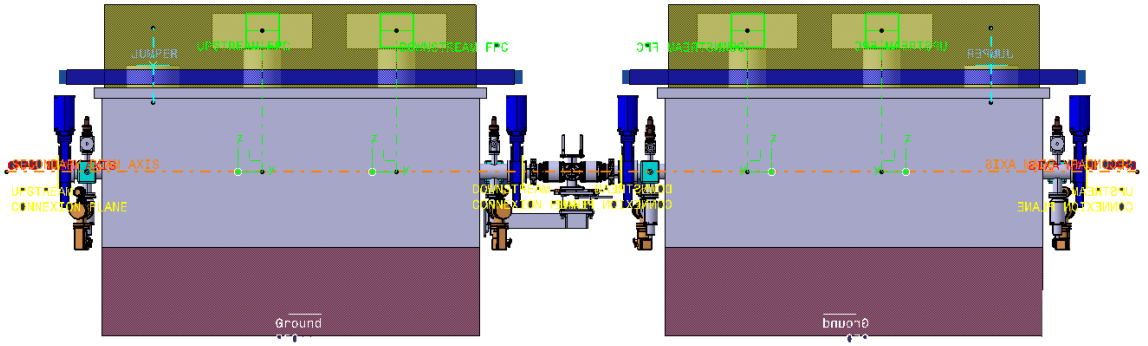


DQW

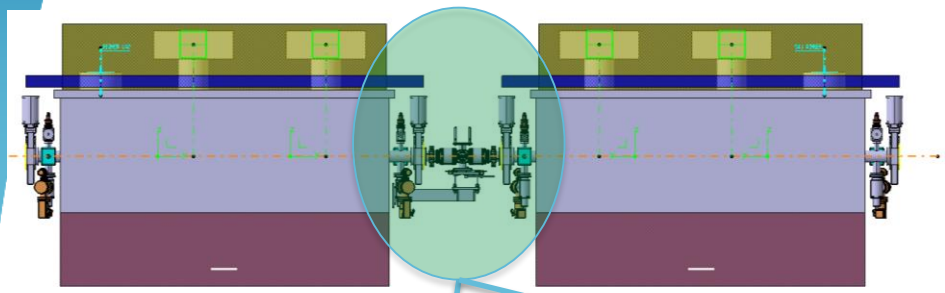
D2



DQW Crab Cavities
LHC – WP15 Integration
(ST1096196_01)



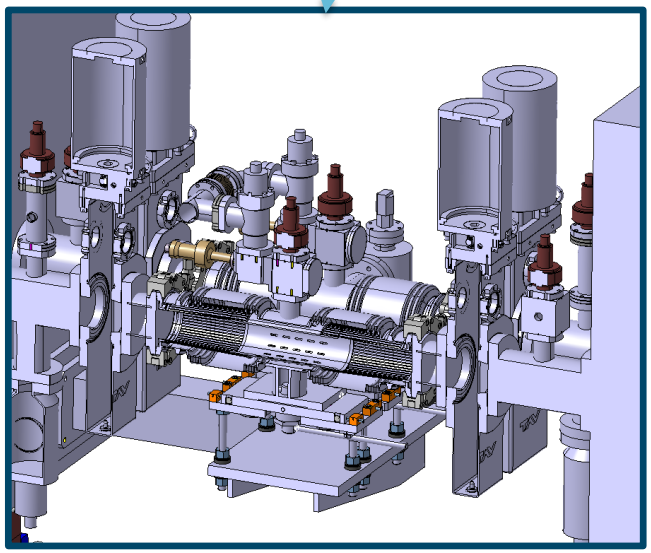
Crab Cavities (vacuum connection between cavities)



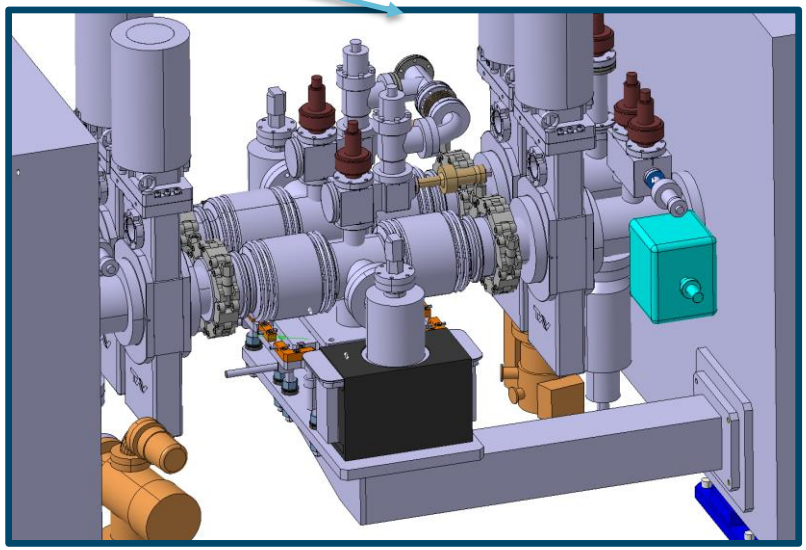
- The beam line pumping modules will be supported by the crab cavities and remotely aligned with the cavities.

- Manual alignment for each beam line required during first installation (no further alignment required).

- The pumping modules are quick connect modules (no alignment required if removed and reinstalled).



Transport side



DFB side

Radius clearance for VAB at D2, Q4 and Q5

Smallest clearance values for VABs on the IP and ARC side of D2, Q4 and Q5

VAB		Smallest clearance after first alignment [mm]	Smallest clearance after moving the RATS
D2	IP side	I&V = 7.5 / E&H = 2.7	I&V = 7.5 / E&H = 2.7
	Arc side	I&V = 8.6 / E&H = 8.4	I&V = 8.6 / E&H = 8.4
Q4	IP side	I&H = 4.4 / E&V = 4.6	I&H = 1.9 / E&V = 2.1
	Arc side	I&H = 6.2 / E&V = 6.4	I&H = 3.7 / E&V = 3.9
Q5	IP side	I&H = 10.5 / E&V = 10.4	I&H = 8.0 / E&V = 7.9
	Arc side	I&H = 8.3 / E&V = 7.9	I&H = 5.8 / E&V = 5.4

Remotely aligned, no impact on clearance

Not remotely aligned, impact on clearance but enough margin

Nomenclature:

- V: vertical;
- H: horizontal;
- I: interior beam line;
- E: exterior beam line;
- RATS: remote alignment transversal stroke.

Note:

Values taking into account the left side of P5

Readiness and risks

- Drawings are in preparation for all new vacuum supports.
- Prototypes of new supports will be ready by end of 2019
- Prototypes supports will be installed on surface beginning of 2020 for WP12 and WP15.4 to perform installation and alignment tests.
- Modification and validation by middle of 2020.
- The procurement shall be ready by end of 2021 (relatively simple components with delivery time of approximately 2 months)

Summary

- The alignment of vacuum component can be done with existing alignment solutions with the help from WP15.4.
- Survey will perform the first alignment during installation of three types of components: transition vacuum chambers (VCT) adjacent to a Deformable RF bridge (DRF), single or double vacuum assembly with sector valves (VAB), double and single bellow vacuum module (VM).
- TE/VSC will be in charge of the alignment of the transition and drift vacuum chambers that are not adjacent to any DRF.
- All vacuum component to be remotely aligned are attached to other components which are remotely aligned ➔ none of these vacuum components require individual alignment
- No realignment foreseen of vacuum components, as the aperture clearance is sufficient, and all components are fitted with targets for easy alignment check.

This presentation has been based on present knowledge. Analysis and conclusions might evolve if the final values will change (meeting on the final documentation between WP2, WP12 and WP15.4 scheduled in Sept 2019)

Thanks for your attention