Alignment of VSC components along LSS 1&5

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Many thanks to Helene Mainaud Durand

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Outline

1. Introduction
2. TAXN-D2 area - ALARA approach
3. Areas under study
4. Summary & next steps

1. Introduction

HL-LHC Beam aperture LSS R5

- Inputs from WP2, Riccardo de Maria (21/04/2016)

Element	S [m] - magnetic length	Beam separation [mm]	Beam aperture [mm]
End D1 (MBXF)	80.939	0	119
Start TAXN	127.135	148	85
End TAXN	130.467	158	85
outside D2 (MBRD)	137.624	180	85
Start D2 (MBRD)	138.624	188	87
End D2 (MCBRD)	146.404	188	85
Start Q4 (MCBYY)	175.685	194	72.41
End Q4 (MQYY)	179.515	194	72.41
Start Q5 (MQY)	205.79	194	57.8
End Q5 (MCBY)	209.19	194	57.8
Start Q6	225.99	194	45.1
End Q6	230.79	194	45.1
Start Q7	260.004	194	44
End Q7	267.171	194	44

*

*from the end of Q4 to the end of Q7, B1 and B2 are not symmetric any more

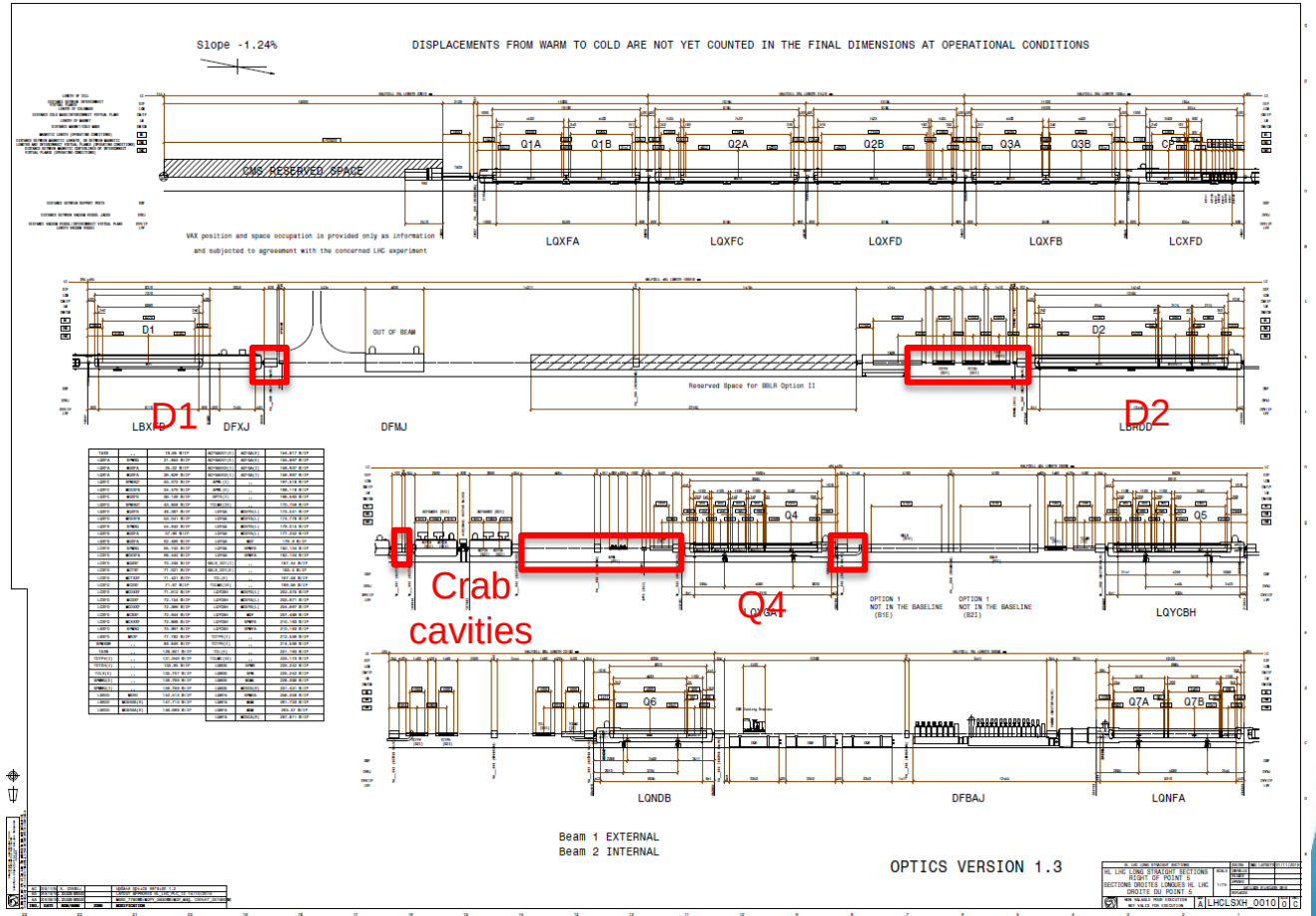
- Since June 2016 re-baselining, Q4 mechanical aperture is reduced to 57.8 mm radial ID and 48.0 mm between flats ID (MQYY replaced by MQY). So, the table* needs to be updated by WP2

When the support of survey is needed for WP12?

- Along the LSS1&5 there are areas that are going to be aligned by VSC and other areas where VSC needs the support of Survey.
  - When survey support is required for WP12?
    1. If fiducialisation is required.
    2. If the mechanical aperture of vacuum components is limited.
    3. If there are ALARA restrictions.

HL-LHC LSSR5

- Room temperature vacuum components might be surveyed in the red areas.

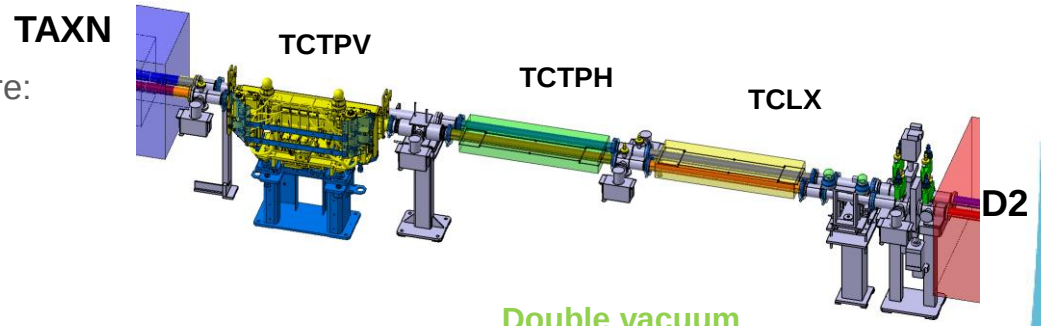


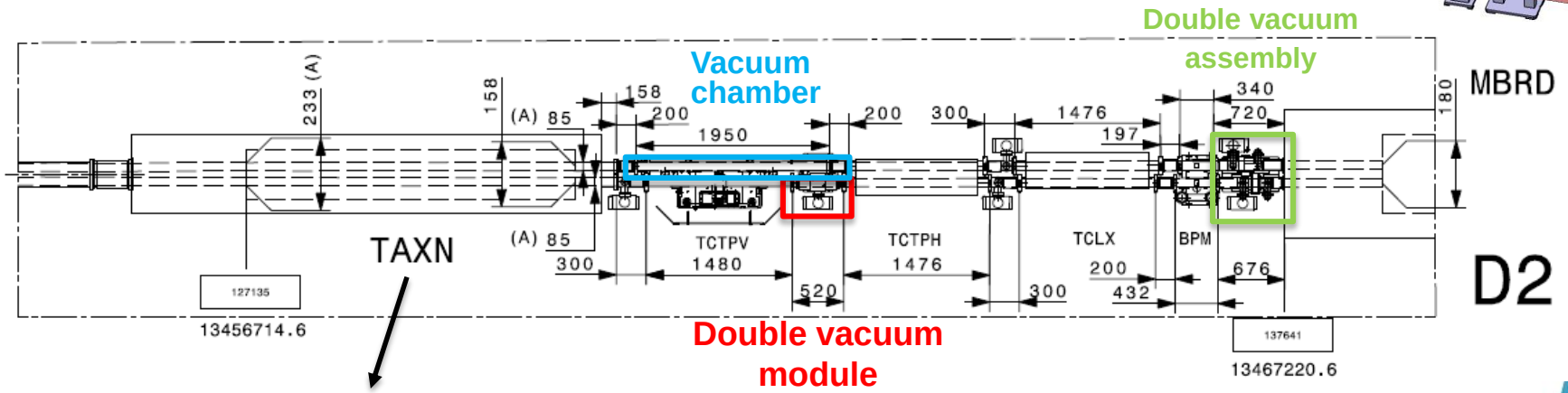
LHCLSXH_0010-v1.3.20 – 04/11/2016, courtesy of WP15

2. TAXN-D2 area ALARA approach

TAXN-D2 area

- The VSC components to be aligned by survey are:
  - A vacuum chamber.
  - A double vacuum module.
  - A double vacuum assembly.





Y-chamber will be located inside TAXN. Its geometry is under study.

S Distance from IP

(A) → Aperture

Mechanical aperture proposed between TAXN and Q4

- In order to reuse between TAXN and Q4 the already vacuum module body design with ID100, the max & min ID and the tolerances for a vacuum chamber and a vacuum module are:

	Min. Inner diameter: 91 mm
Pipe Mechanical tolerance budget*	1.8
Total budget for alignment for a pipe* - TBAP	4
Vacuum module Mechanical tolerance budget*	2.35
Total budget for alignment for a vacuum module* - TBAVM	3.65

Baseline

*Dimension given in diameter

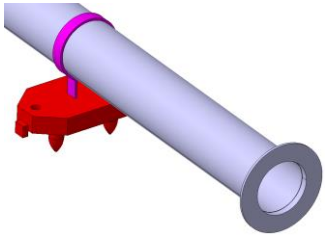
- To achieve a TBAP of 4 mm and to follow ALARA requirements a new VSC supporting system is required. In the following study, only the pipe alignment is considered. It has:
  - 1.8 mm in diameter for mechanical tolerance (like in LHC).
  - 4 mm in diameter are available for the alignment system.

Conceptual ALARA Alignment & Supporting Assy

- The objective of the ALARA supporting system is to exchange a component assembly **without** redoing its alignment. The ALARA supporting system must be aligned only once by Survey.

- The vacuum assembly (VA) is composed by two main sub-assemblies:
  - Component assembly
  - Supporting system

Survey Targets



Component Assembly

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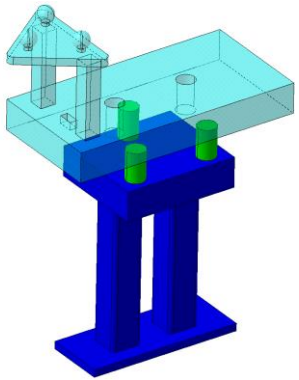

Supporting System:
aligned by survey

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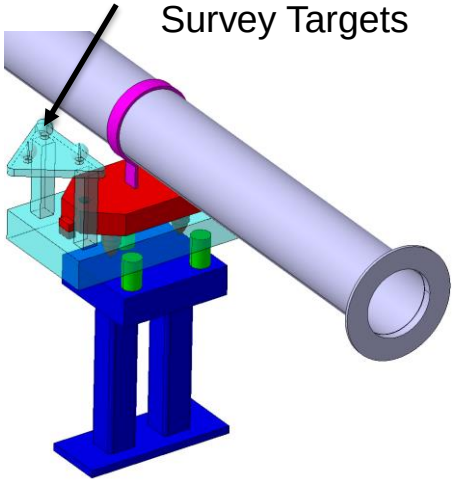
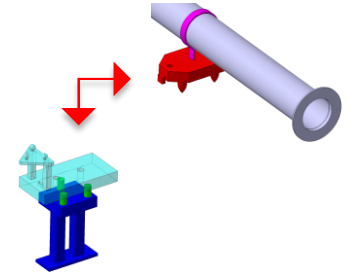


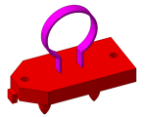
Vacuum Assembly (VA)
In case of a pipe

Performances specification for a pipe

- The total budget for alignment for a pipe, TBAP, is 2mm in radial (4 mm in diameter). The breakdown of the TBAP is:
  - 0.2 mm for the survey target accuracy.
  - 1 mm for smoothing.
  - 0.8 mm for the connecting part mechanical tolerance plus the reproducibility accuracy of the component exchange.



Reproducibility accuracy



Connecting part

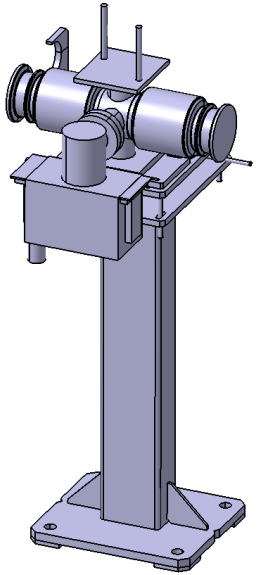
	Identification number	Description	mm	Carry out by
Total Budget for Alignment for a Pipe*, TBAP, is 2mm	TAA	Free station in local network* (including Targets Alignment Accuracy)	0.2	SURVEY
	ST	Smoothing Tolerance*	1[&]	SURVEY
	RA + CPMT	Reproducibility Accuracy* + Connecting Part Mechanical Tolerance*	0.8	VSC

*given dimensions are in radius
[&]to be confirmed by survey

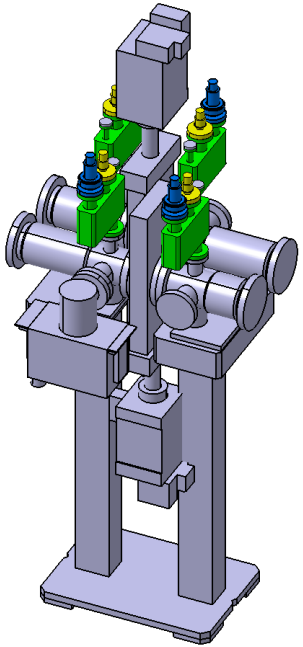
Performance specification is more detailed in WP12 "2nd internal integration meeting" (https://indico.cern.ch/event/586074/)

Performances specification for other components

- Performance specifications for vacuum modules (VM) and vacuum valves assemblies (VAB) to be studied.



Vacuum modules assembly (VAM)
Collimator pumping assembly, ID91



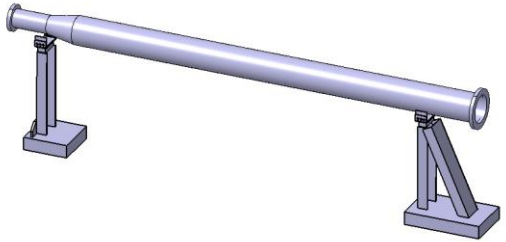
Vacuum valves assemblies (VAB)
Staggered valves, ID 100

3. Areas under study

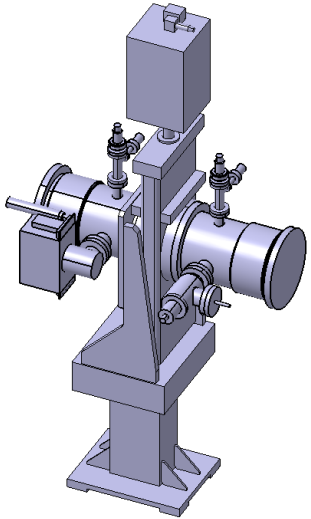
DFX area: cryogenic type beam pipe

- Area under study.
- There are two main options to be studied:
  - A single vacuum assembly with ID 150 sector valve next to DFX.
  - A single vacuum assembly with ID 200 sector valve next to DFX.

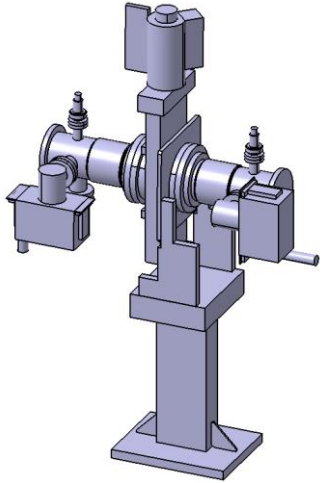
- In the case with a cryogenic type beam pipe, survey intervention will probably be required to align one vacuum assembly with a sector valve, VAB, and one vacuum chamber transition, VCT.



Vacuum chamber transition, VCT



Vacuum assembly with sector valve with ID 150 similar to VALHR installed in LHC LSS2

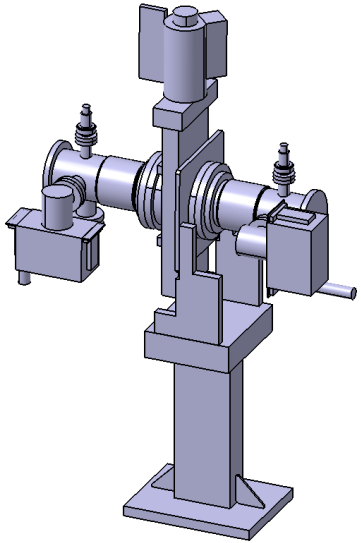


Vacuum assembly with sector valve with ID 150 similar to VASCA installed in LHC LSS6

Survey targets to be included in the design in case the alignment is carry out by Survey.

DFX area: RT type beam pipe

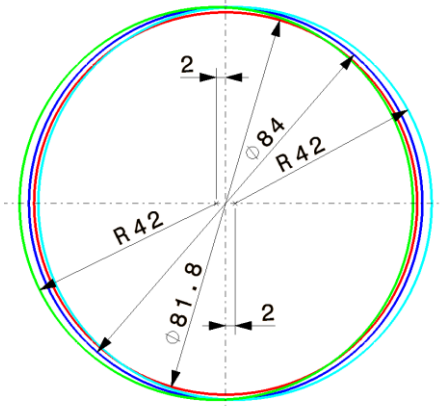
- Area under study with a single vacuum assembly with ID150 sector valve next to D1.
- In the case with a room temperature type beam pipe survey intervention will probably not be required.



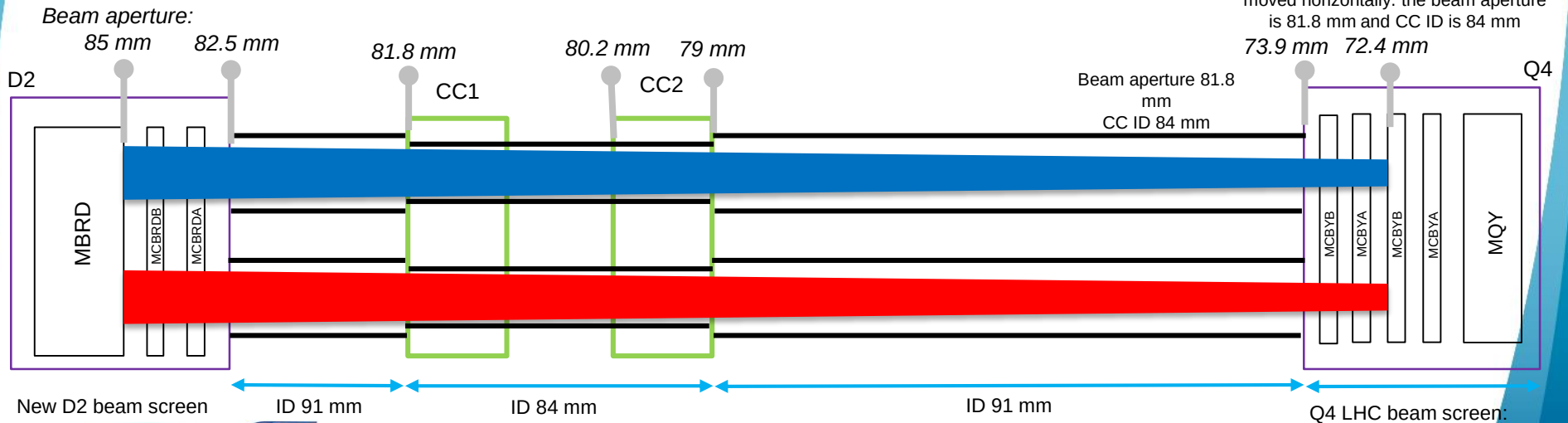
Vacuum assembly with sector valve with ID 150 similar to VASCA installed in LHC LSS6

D2 - Q4 area

- If Crab Cavities are remotely moved radially by +/- 2 mm VSC components between D2 and CC1 must be align with high accuracy, so might be a potential issue and, in the case a VSC component exchange, SU will have to re-align. However, the VSC components between CC2 and Q4 are aligned by VSC.
- Q4 LHC beam screen aperture between flats is 48 mm and beam aperture is 72.4 mm.



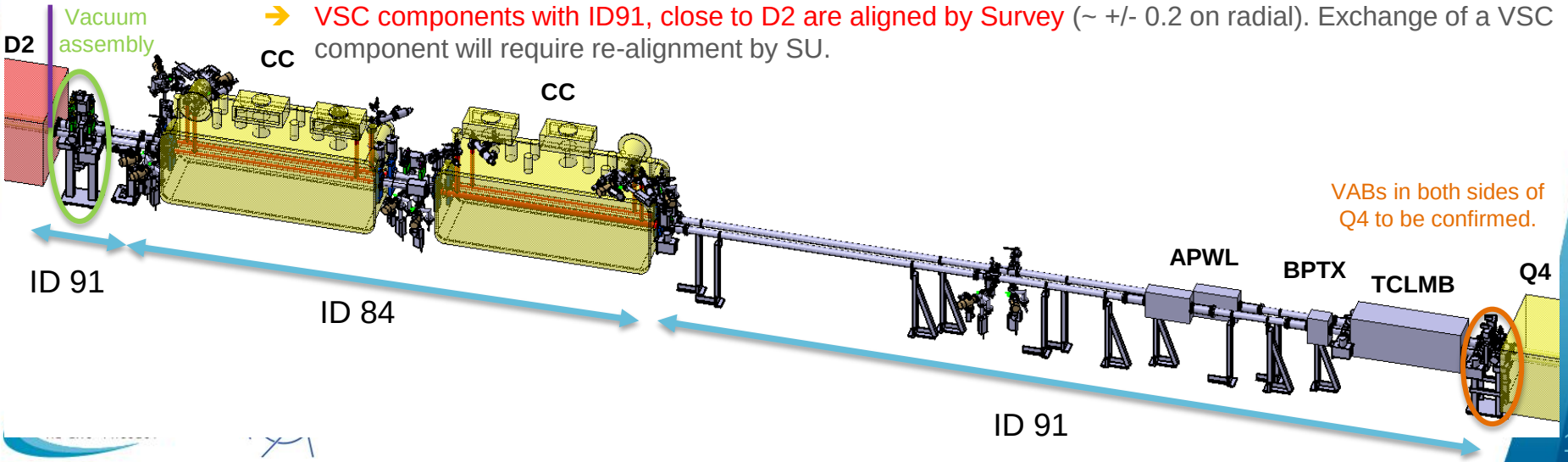
Section cut at CC1 start when CC are moved horizontally. the beam aperture is 81.8 mm and CC ID is 84 mm



B1 B2

D2 - Q4 area

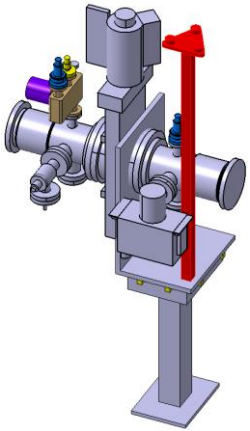
- Since the beam aperture at D2 flange (A) is 82.5 mm and the crab cavities cryomodule mechanical aperture is 84 mm, the proposed mechanical aperture between D2 and Q4 is 91 mm except for the vacuum module located between the cryomodules which has an ID of 84 mm.
- Q4 and TCLMB might have a motorized system for remote alignment. In consequence, the alignment performance of the two VABs (of LHC type) located on both sides of Q4 must be reviewed in order to clarified if they need to be aligned by SU.
- Since the cryomodules might be remotely aligned within 2 mm. There are two scenarii:
  1) CC with ID 84 mm and without movement:
     - ➔ For VSC components with ID91 the alignment is carry out by VSC (+/- 2 mm on radial).
  2) CC with ID 84 mm that moves +/- 2 mm horizontally:
     - ➔ VSC components with ID91, close to D2 are aligned by Survey (~ +/- 0.2 on radial). Exchange of a VSC component will require re-alignment by SU.



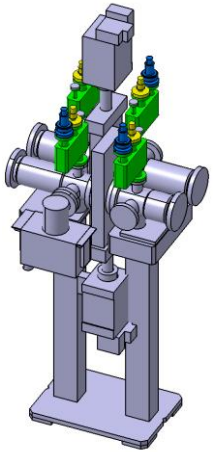
4. Summary & next steps

Vacuum components types to be aligned by SU

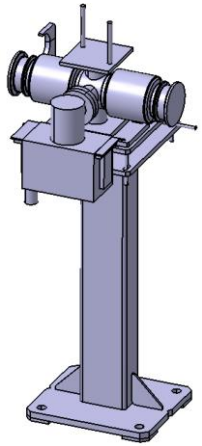
- VSC components to be aligned by SU:
  - TAXN-D2 area:
    - 1 vacuum chamber.
    - 1 double vacuum module.
    - 1 double vacuum assembly.
- VSC components might require SU alignment in the following areas:
  - DFJ area.
  - D2-Q4 area.



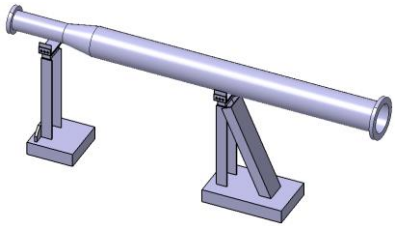
Single vacuum assembly



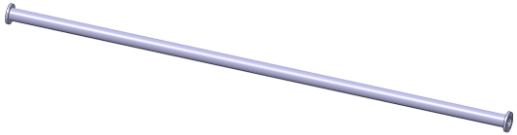
Double vacuum assembly



Double vacuum module



Vacuum chamber transition



Vacuum chamber

Summary

- Following the study case of a vacuum chamber supporting system with a total alignment budget of 2 mm in radius, the alignment performances specifications are:
  - Smoothing tolerance (ground motion): 1 mm.
  - Targets alignment accuracy wrt the magnets: 0.2 mm.
  - Performance of the new alignment and supporting system must be better than 0.8 mm.

- D2-Q4 area:
  - In case crab cavities have ID 84 mm and are fixed, VSC components with ID91 are aligned by WP12.
  - In case Crab cavities have ID 84 mm and can be displaced +/- 2 mm horizontally, a exchange of a VSC component will require re-alignment by SU.
  - LHC Q4 beam screen aperture between flats is 48 mm and the beam aperture at D2 magnet, MQY, is 72.4 mm.

Next steps

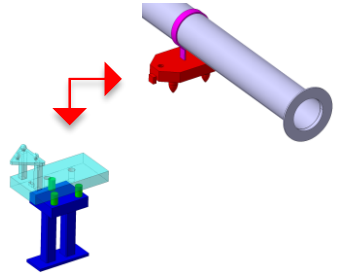
- Beam aperture table along LSS 1&5 to be updated by WP2.
- Complete the list of:
  - Vacuum components to be aligned
  - Vacuum chambers to be fiducialised.
- Check if the two VABs in both sides of Q4 should be aligned by survey.
- Identify and define the H,V and tilt tolerances for bellows and cold warm transitions.
- Define the fiducialization tolerances.
- Define Y-chamber geometry in order to define TAXN alignment specifications.
- ALARA Alignment & Supporting Assembly:
  - Study the performances specifications in the cases of a vacuum module and the VABs.
  - Freeze performance specification.
  - Design of the Vacuum assembly (VA).

THANK YOU FOR YOUR ATTENTION!!!

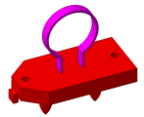
Backup slides

Performances specification for a pipe

- The total budget for radial alignment, TBAP, in case of a pipe equals 2 mm.
- The TBAP is the sum of the mechanical tolerance of vacuum assembly, MTVA, the reproducibility accuracy, RA, and the smoothing tolerance (ground motion), ST.
- After the alignment by SU of the supporting system, the MTVA is reduced to the sum of the target alignment accuracy, TAA, plus the mechanical tolerances of the connecting part, CPMT.
- TAA is assumed to be equal to 0.2 mm, and the ground motion, ST, is assumed to be equal to 1 mm.
- Thus,
  - TBAP = MTVA + RA + ST = TAA + (CPMT + RA) + ST.
- The connecting part mechanical tolerance plus the reproducibility of installation equals therefore 2 – 0.2 – 1 = 0.8 mm.
- So, the performance of the new alignment and supporting system to be designed by VSC must be better than 0.8 mm.



Reproducibility accuracy



Connecting part

Identification number	Description	mm	Carry out by
TBAP	Total Budget for Alignment for a Pipe*	2	-
TAA	Free station in local network* (including Targets Alignment Accuracy)	0.2	SURVEY
ST	Smoothing Tolerance*	1[&]	SURVEY
RA + CPMT	Reproducibility Accuracy* / Connecting Part Mechanical Tolerance*	0.8	VSC

*given dimensions are in radius
[&]to be confirmed by survey

Performance specification is more detailed in WP12 "2nd internal integration meeting" (https://indico.cern.ch/event/586074/)