WP12 Crab Cavities preliminary layout study

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OUTLINE

1. Introduction.
2. Crab cavities.
3. Vacuum layout proposal.
4. Conclusions & next steps.

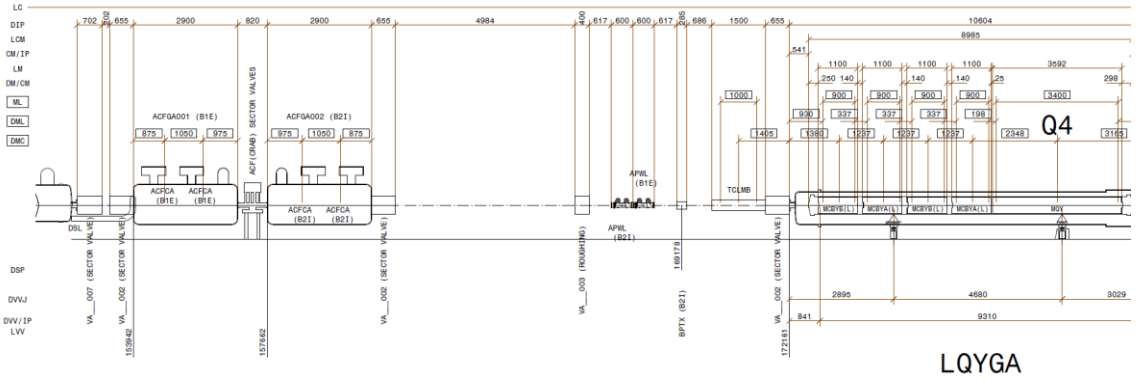
1. Introduction

Motivation & inputs

- **The crab cavities mock-up and the vacuum layout between D2 and Q4 must be defined and set.**

- **The inputs used in this study are the following:**
  - **HL-LHC LSS R5 layout: LHCLSXH_0010 v1.3.**
    - Courtesy of Blanca Vazquez De Prada & Ignacio Zurbano Fernandez (28/10/2016).
  - **Beam aperture between D2 and Q4: ID91 mechanical aperture in room temperature beam pipe and ID84 in cryomodule.**
    - Courtesy of Riccardo de Maria (21/04/2016) and Rama Calaga.
  - **"HL-LHC layout update and ongoing optics work" presented in 16th HiLumi TCC Meeting.**
    - Courtesy of Riccardo de Maria (22/09/2016).
  - **HL-LHC Crab Cavities mock-up: ST0782198_01*.**
    - Courtesy of Teddy Capelli (23/06/2015).

D2



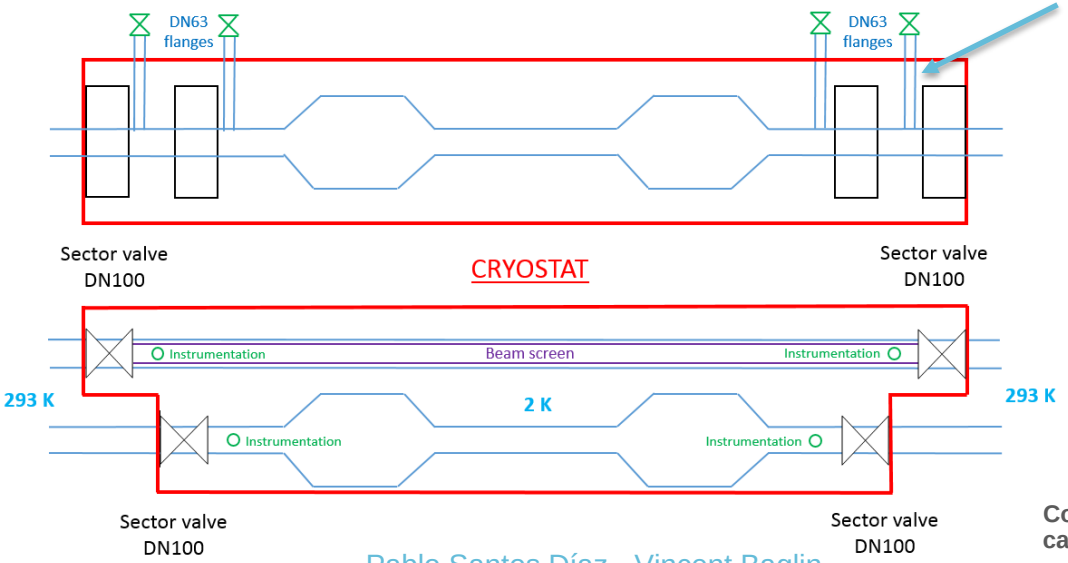
Q4

*Still under prototyping

2. Crab cavities cryomodule

VSC specifications

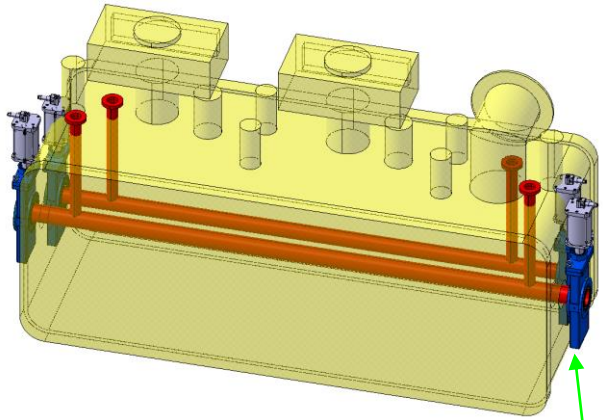
- In order to guarantee vacuum stability, the non-crabbed vacuum chamber, operating at 2K, needs to be designed with a perforated beam screen type system operating at 5-20K.
- To separate room temperature from cold temperature pipes, 4 Sector valves DN100 in each crab module are required. They will allow conditioning of the cryomodules at the surface.
- The 4 sector valves are interlocked to the beam
- Two connection pipes per beam line are required in the cryomodule to provide the required vacuum instrumentation.

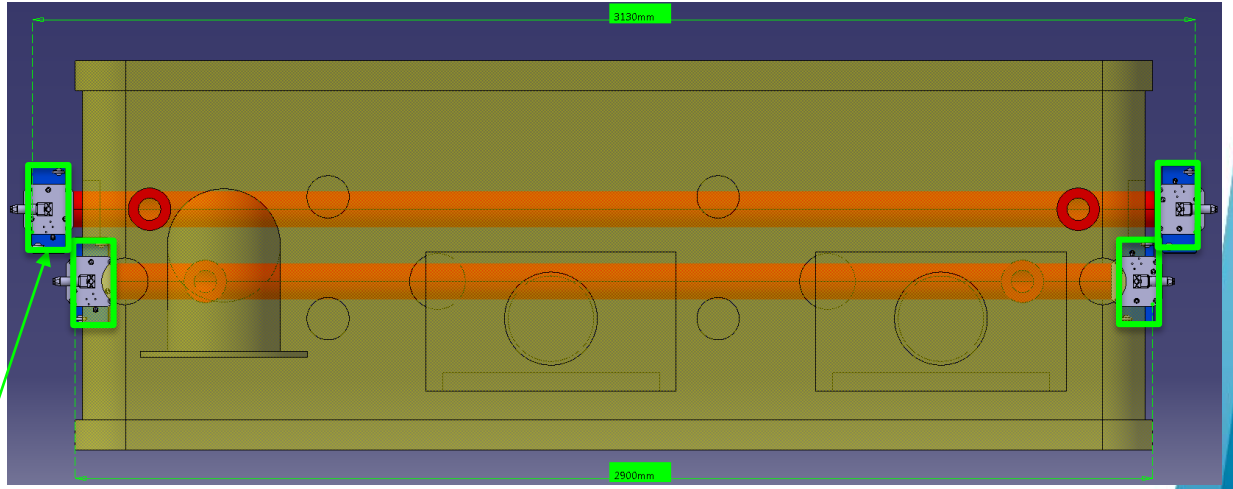


Conceptual VSC Crab cavities configuration proposal

Cryomodule envelope

- The cryomodule sector valves must be staggered due to the 194 mm beam separation. So, there is different cryomodule envelope length for crabbed and non-crabbed beams.
  - The estimated length for the non-crabbed sector inside CC cryomodule is 3130 mm → tbc with WP4.

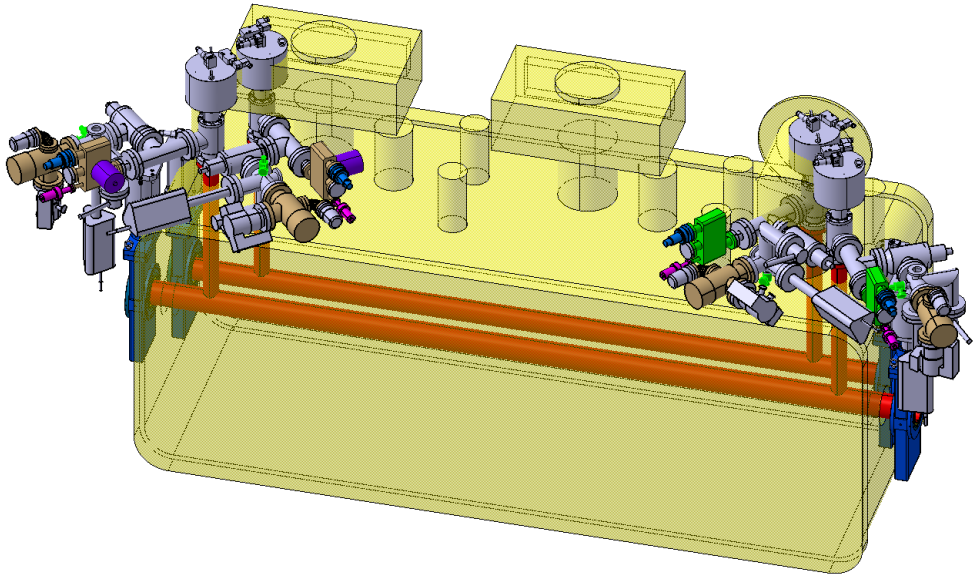




Sector valve

Cryomodule with VCS instrumentation

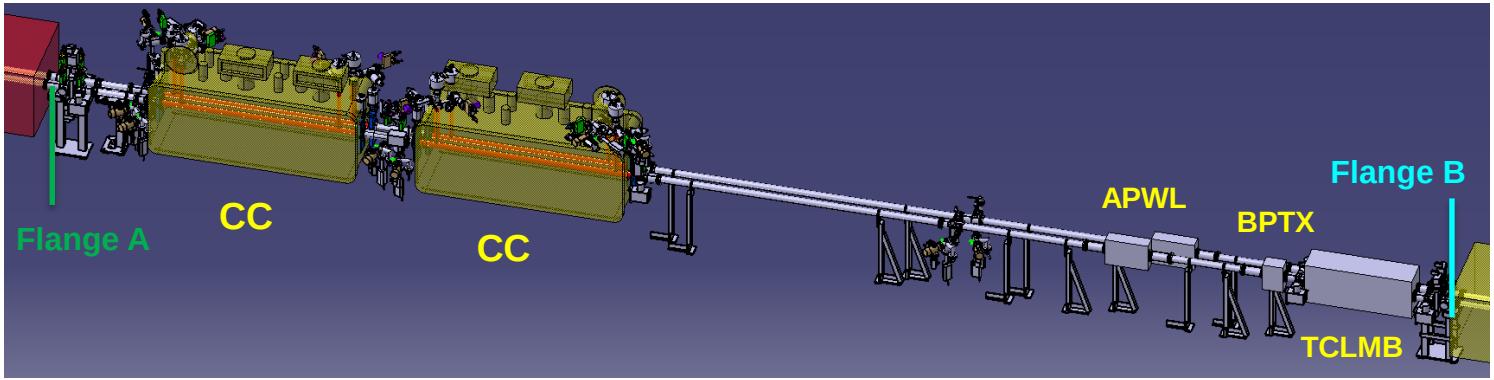
- Adding the required vacuum instrumentation …
  - many interferences with the present crab envelope appears !
    → crab cavities mock-up should be defined taking into account VSC equipment
    → iterations with WP4 are needed



Cryomodules integration study for the DQW (left) and RFD (right) cavities with VC ID 91 mm

3. Vacuum layout proposal

Vacuum layout proposal between D2-Q4

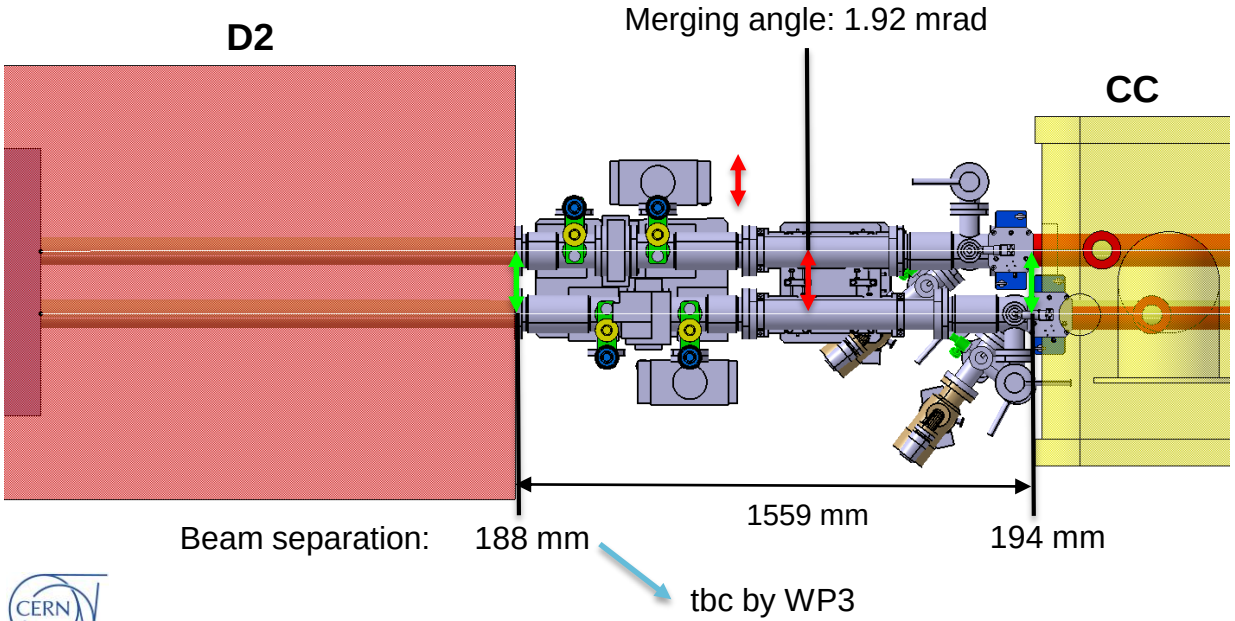


- 3 double room temperature sectors bakeable, NEG coated.
- 2 sectorized CC modules: unbaked and operating at cryogenic temperature.
- 3 types of sector valves assemblies (VAB).
- Since the mechanical aperture is 91 mm, DN100 flanges are required.
- The beam separation at the flange A is 188 mm and at flange B is 194 mm (to be confirmed by WP3).
  - There must be a mechanical merging angle between these flanges.

New VAB next to D2 with merging angle

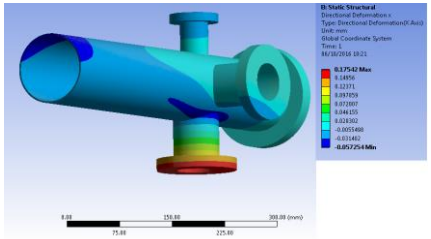
- Due to the difference between the beam separation in D2 (188 mm) and in CC (194 mm), there must be a mechanical merging angle between D2 flange and CC flange.

  → a special VAB configuration needs to be studied.

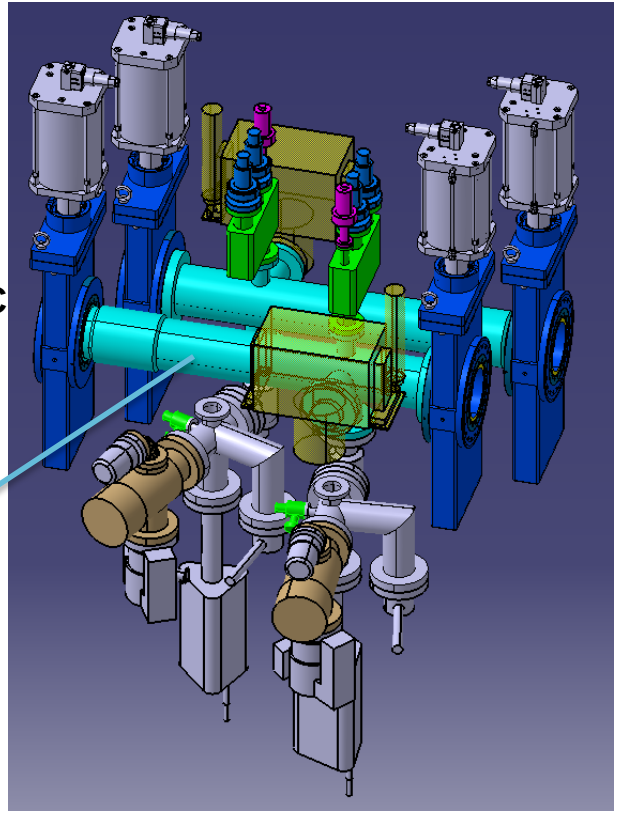


New VAB between crab cavities

- A special vacuum module must be designed with the following specifications:
  - Installed vacuum module length equal to 725 mm.
  - Enough strength to support all the instrumentation required in a vacuum sector.
  - The vacuum module must be bakeable up to 250 °C.
  - Flanges DN100.
  - NEG coated.

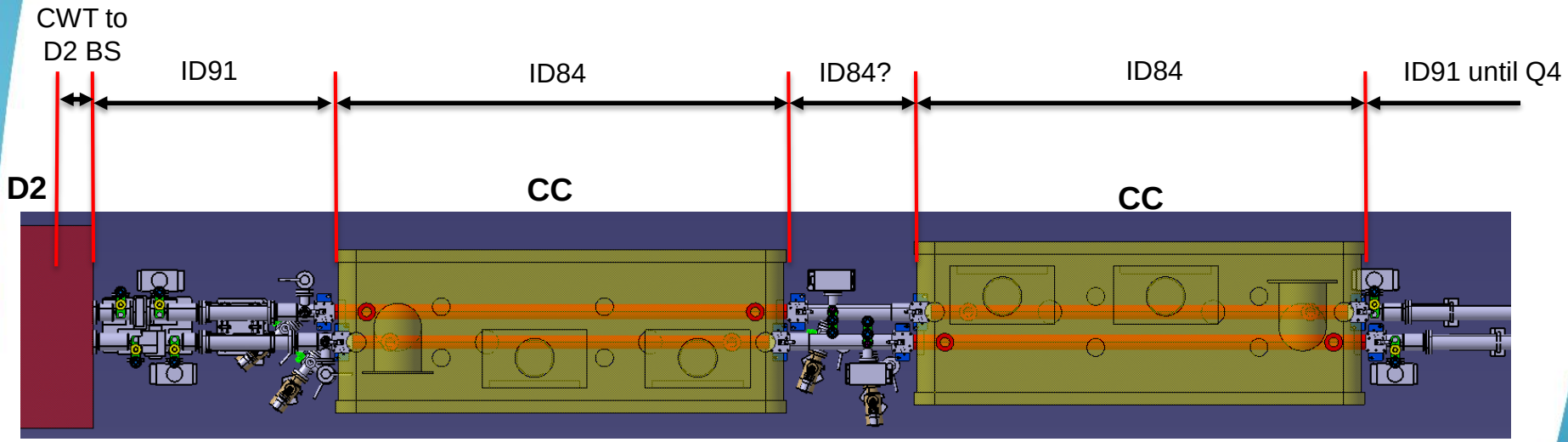


New vacuum module stress analysis



Mechanical aperture between D2 and Q4

- There are different mechanical apertures between D2 and Q4.
  → They must be studied in detail to define the positions of the ID transitions.



4. Conclusions & next steps

Conclusions

- A vacuum layout between D2 and Q4 is under study
- This layout includes VSC specifications.
  → to be validated by WP4 and WP15.

- The studied layout includes:
  - 3 double room temperature sectors bakeable and NEG coated.
  - 3 types of sector valves assemblies (VAB).
  - Flanges DN100 for the connections among equipment.
  - 2 double vacuum sectors per CC module: unbaked and operating at cryogenic temperature.
  - VCS crab cavities specifications:
    - Non-crabbed vacuum chamber with perforated beam screen type system.
    - 4 Sector valves DN100 per CC module.
    - Two connections pipes per beam line per CC module for vacuum instrumentation.

- New VAB next to D2 must have a merging angle.

- There are different mechanical apertures between D2 and Q4 which needs to be defined.

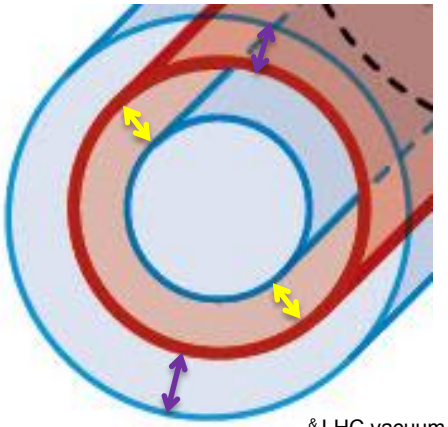
Next steps

- HL-LHC crab cavities module envelope needs to be validated by WP4.
- VSC specifications need to be implemented in the CC module.
- The VAB next to D2 needs to be studied and defined.
- The different mechanical apertures along the layout needs to be studied and defined.
- …

THANK YOU FOR YOUR ATTENTION!!!

Minimum ID of HL-LHC VAC components for 85 mm beam aperture

- Inputs:
  - **Beam aperture**: 85 mm.
- It must be set to compute the minimum ID:
  - **Pipe mechanical tolerance**[&].
  - **Pipe alignment tolerance***.



Vacuum chamber dimensions		
Beam Aperture	85	[mm]
Pipe mechanical tolerance budget**	1.8	[mm]
Pipe alignment tolerance budget**	4	[mm]
Min. Inner pipe diameter	**91**	[mm]
Thickness pipe (2x)	3	[mm]
Min. Outter pipe diameter	**97**	[mm]

**Dimension given in diameter

85 + mechanical tolerance = 85+1.8 = 86.8

86.8 + alignment tolerance = 86.8+4 = 90.8 ➔ 91 mm ➔ DN100 flange

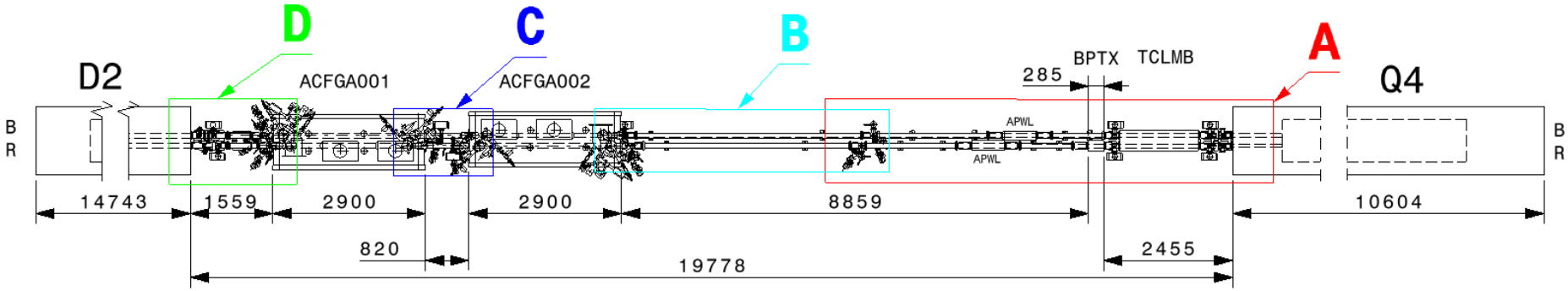
The minimum inner diameter is 91 mm.
The minimum outer diameter is 97 mm.

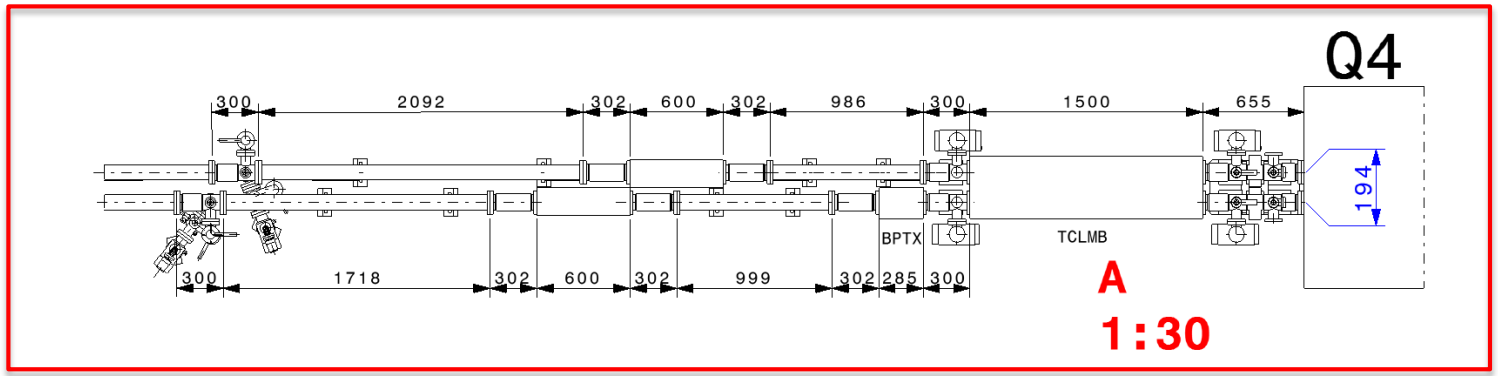
[&] LHC vacuum chamber ID100 Mech. Tol. → Cylindricity = concentricity + straightness + parallelism = 1.8 mm (dimension given in diameter)

* Today for LHC = 4 mm (dimension given in diameter)

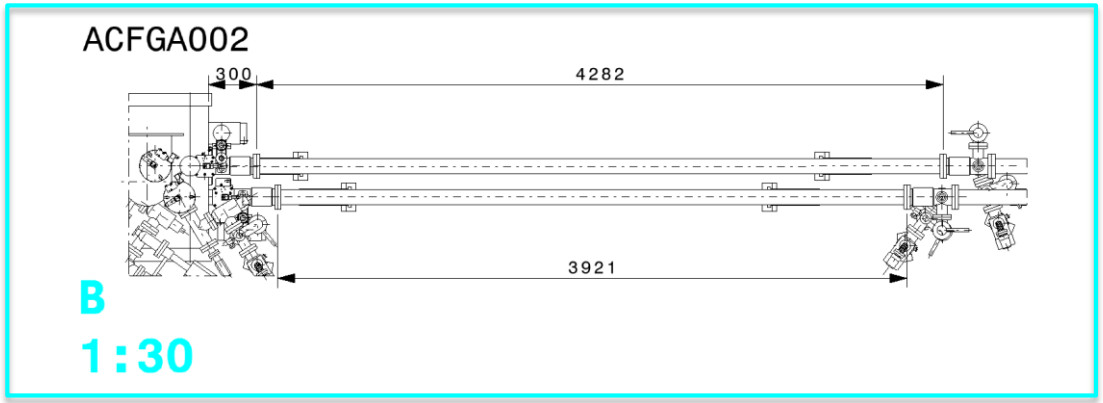
For more info more detailed see presentation "Vacuum layout between D2 and TAXN" presented in HL-LHC Integration Meeting n43 on 29 Apr 2016.

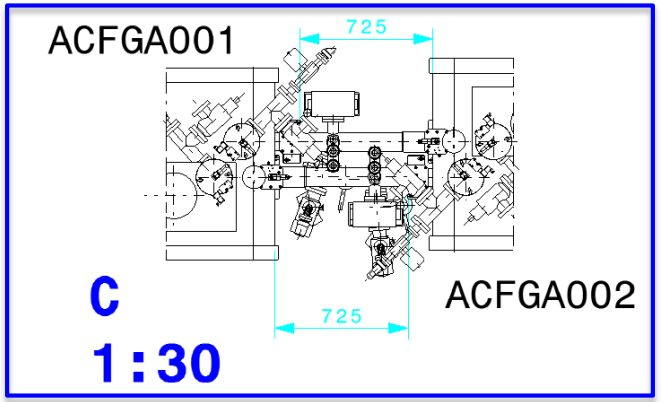
Detailed vacuum layout study [I]

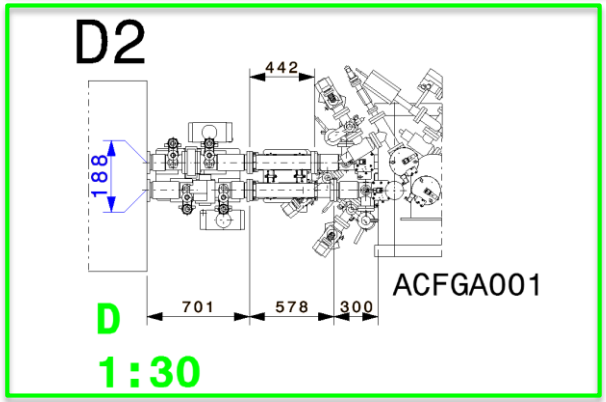


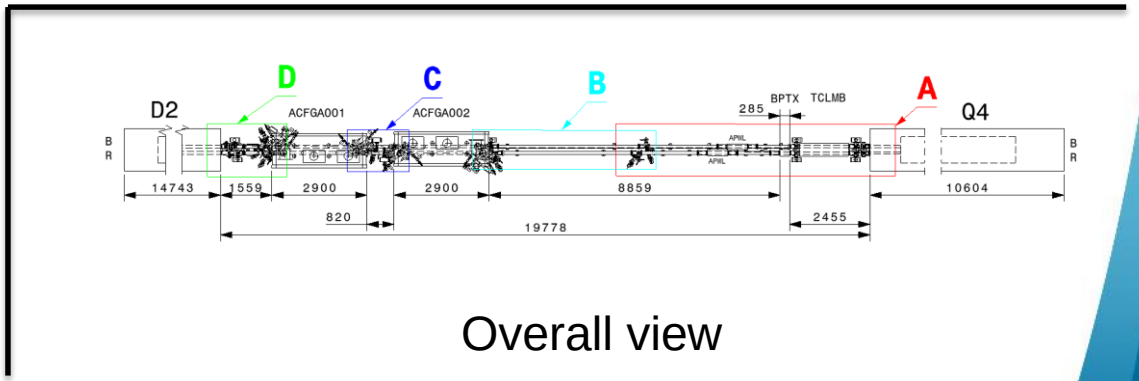


Detailed vacuum layout study [II]









Overall view