HL-LHC tolerances of alignment in LSS1 and LSS5

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With input from R. Jones, C. Boccard, J. Wenninger, P. Santos Diaz, V. Baglin, S. Redaelli, R. De Maria, F. Cerutti, F. Sanchez Galan, SU team, etc.

ENGINEERING DEPARTMENT

HL-LHC integration meeting

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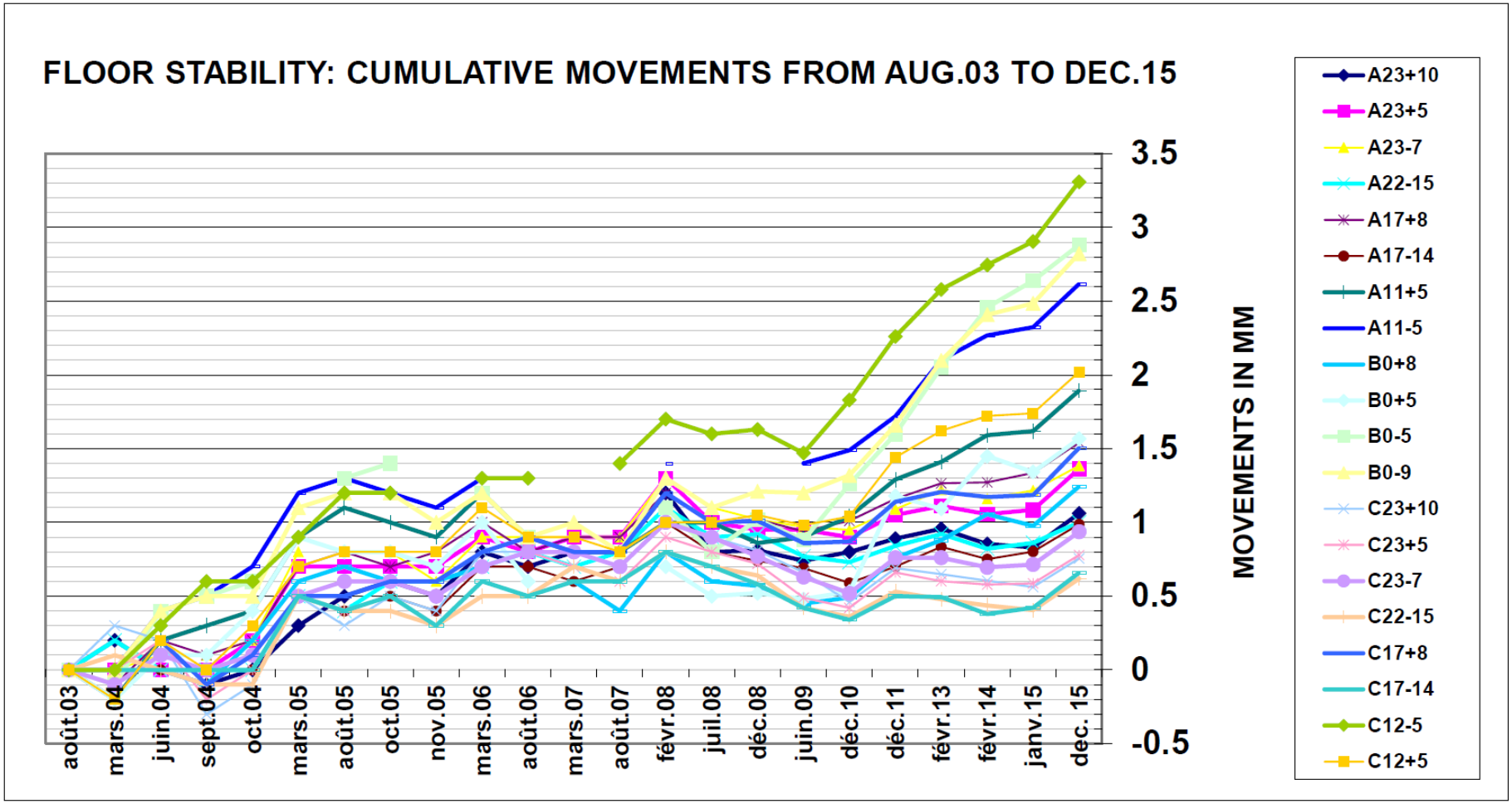
Ground motion in ATLAS

D. Mergelkuhl, edms n°1611954



Ground motion in ATLAS

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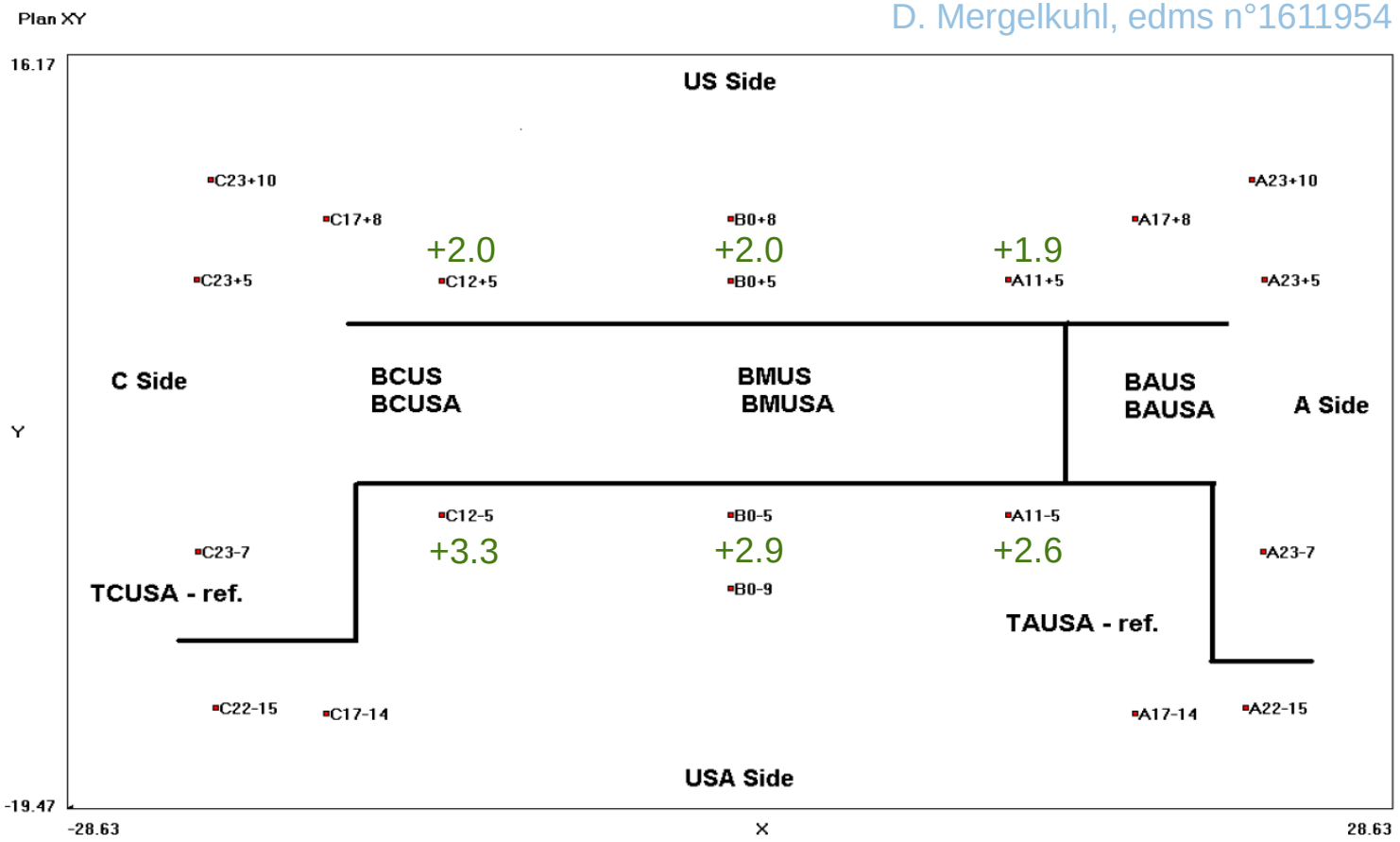
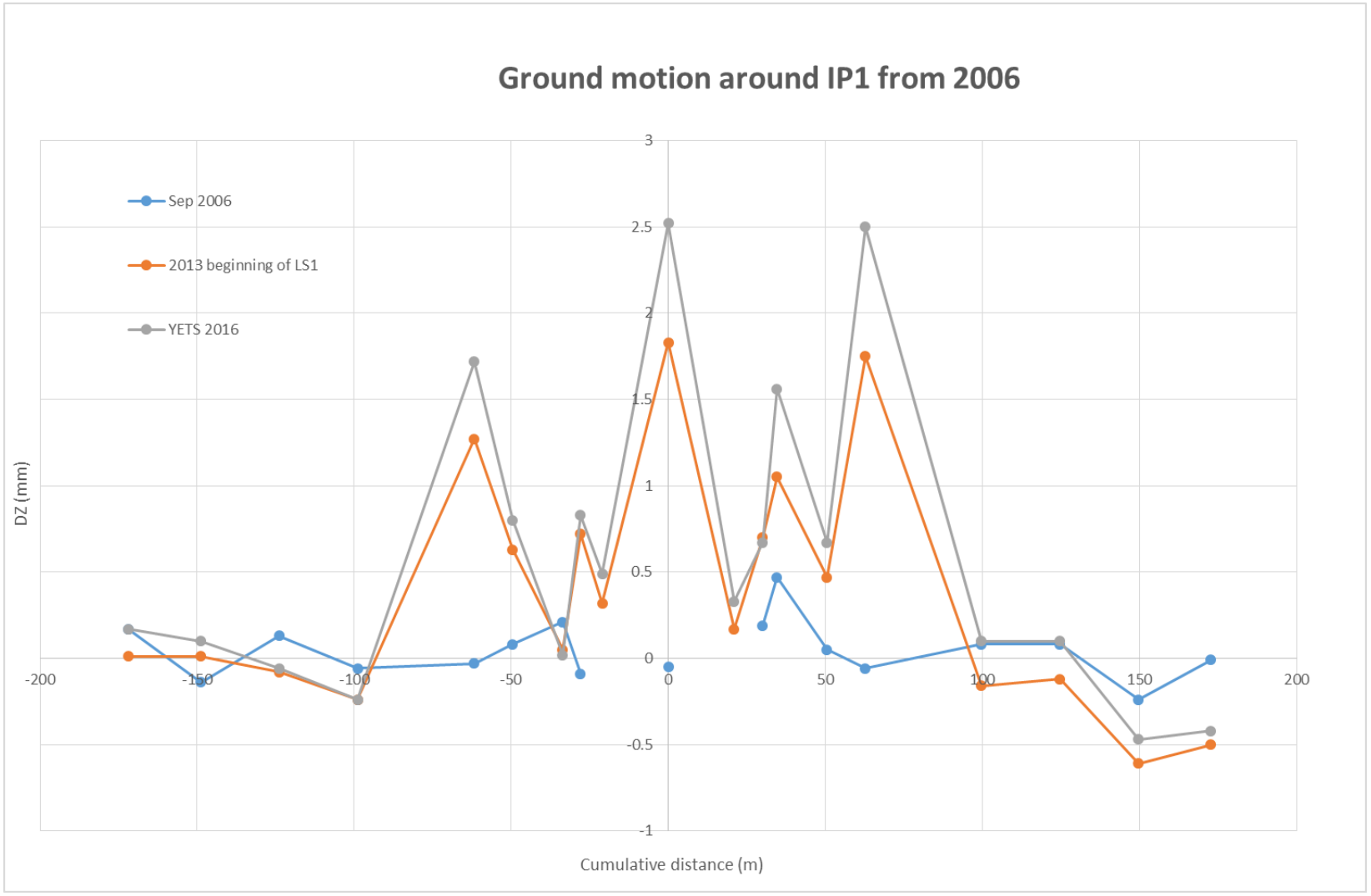


Figure 2 : Positions and names of the stability floor points and bed-plates HLS sensors
*(**C12-5, A23-7, …** : points on floor – **BCUS, …** : HLS sensor on bed-plate, **TCUSA** and **TAUSA** : references HLS system)*

Ground motion in LSS1

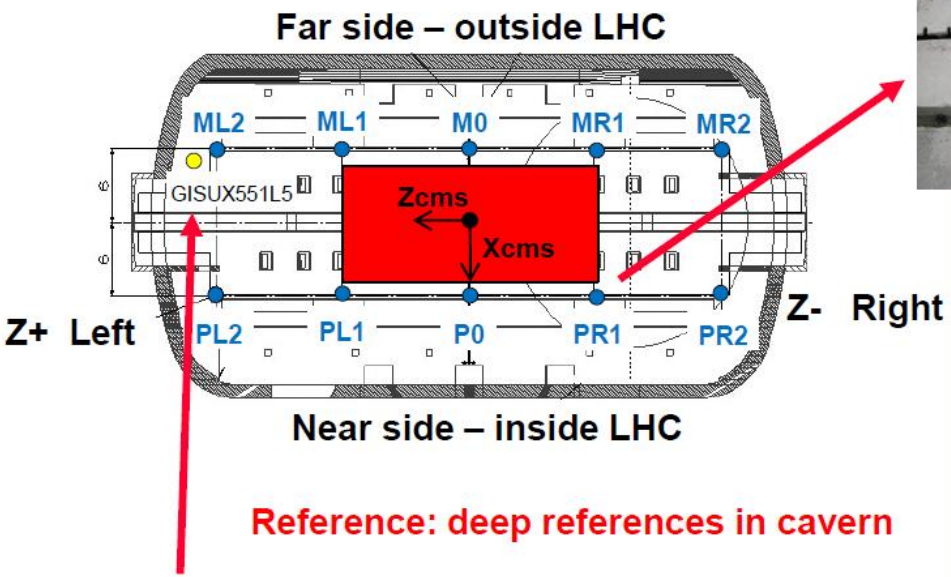
D. Missiaen, edms n°1233554

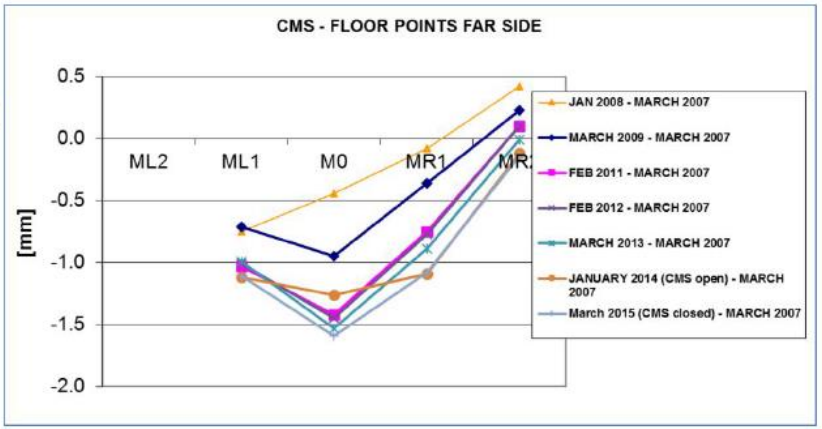


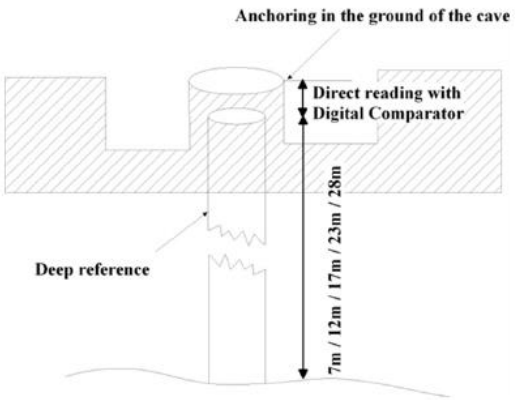
Ground motion in CMS

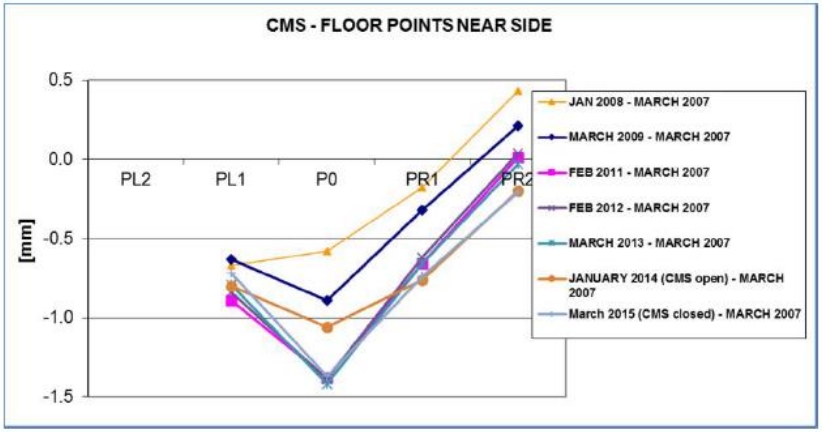
A. Behrens

Stability: Cavern floor leveling



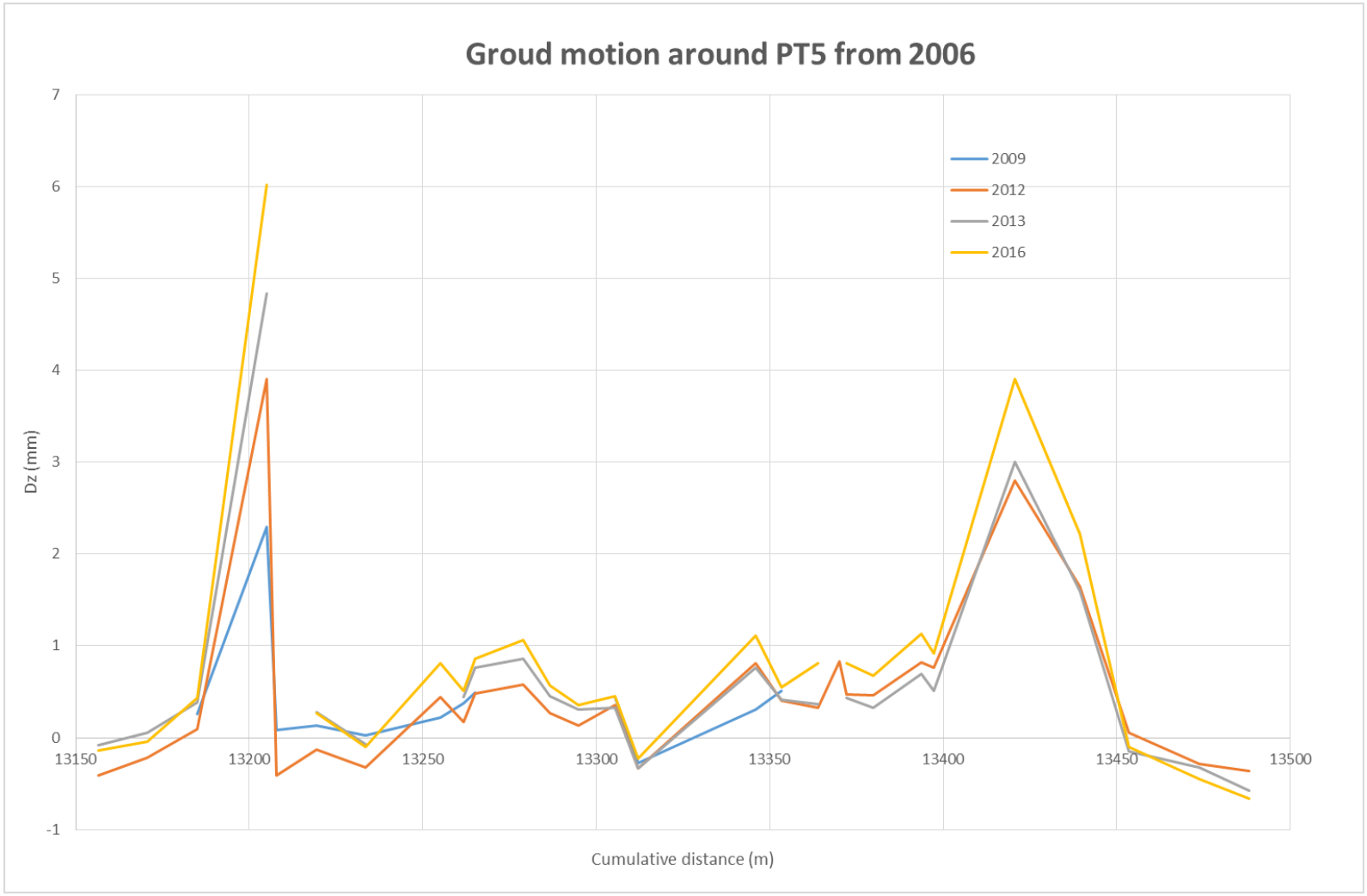






Ground motion in LSS5

D. Missiaen, edms n°1233554



Proposal concerning jacks stroke (To be discussed)

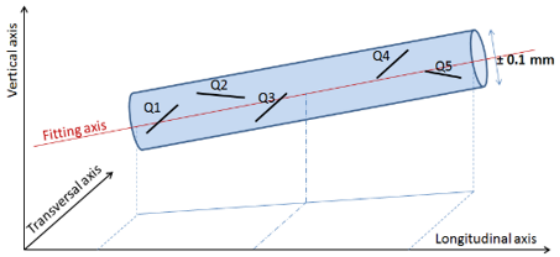
- Max displacements are observed at point1:
  - ~ +0.25 mm/year near the center of the cavern floor
  - ~ + 0.25 mm/year max between the cavern and tunnel points
  - ➔ max. displacements of tunnel points 2.5 mm for 10 years or 5 mm for 20 years
- One specific area: D2-Q4: impact of civil engineering works not know yet.

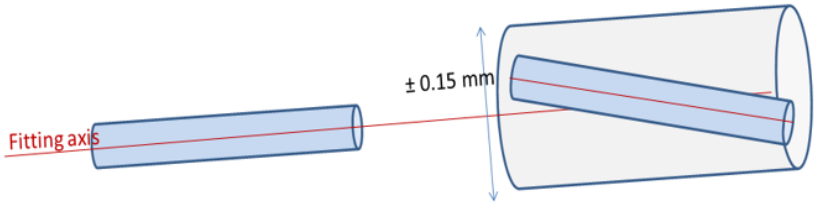
A small reminder of the baseline

HL-LHC requirements

- Machine performance

CERN-ACC-2015-0014





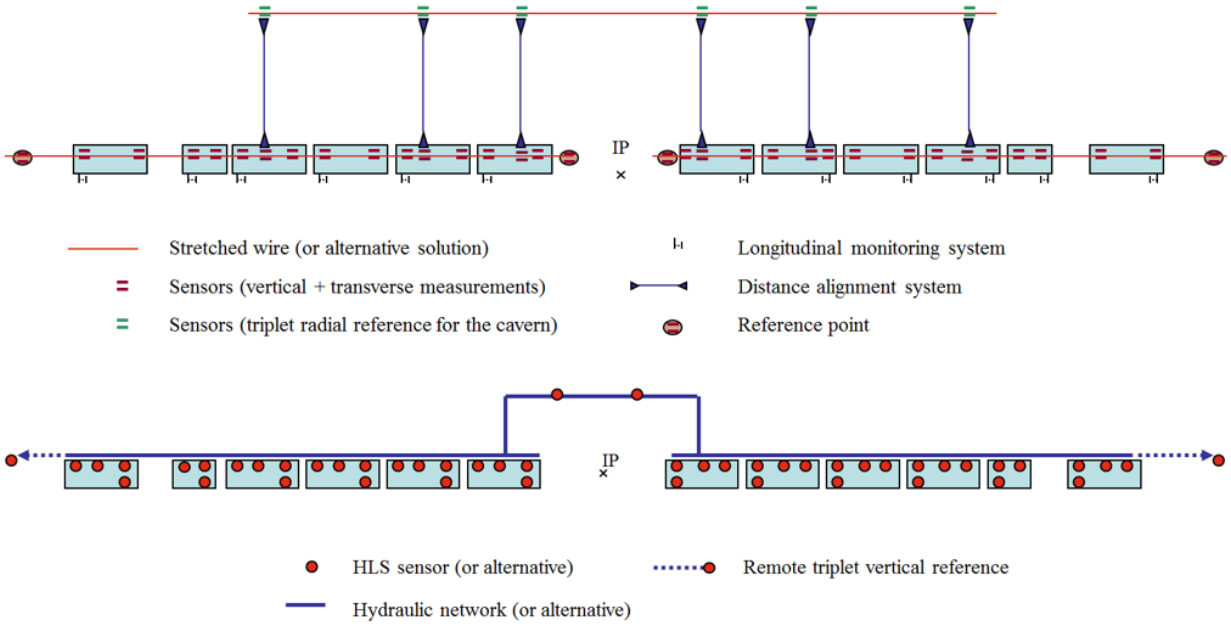
Transverse alignment error (1σ) $\pm\sqrt{(\pm 0.1)^2_{\text{fid}} + (\pm 0.1)^2_{\text{align, side}} + (\pm 0.15)^2_{\text{align, left/right}} + (\pm 0.17)^2_{\text{mis}}}\ \text{mm} = \pm 0.27\ \text{mm}$

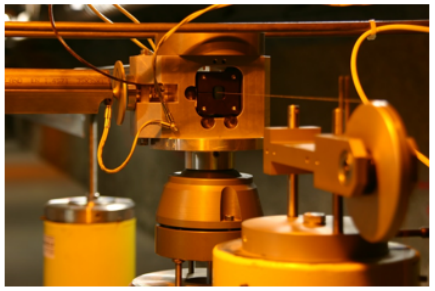
- Remote adjustment of the position of the HL-LHC components from Q1 to Q5 according to 5 DOF (resolution < 10µm, stroke ± 2 mm TBC)

A small reminder of the baseline

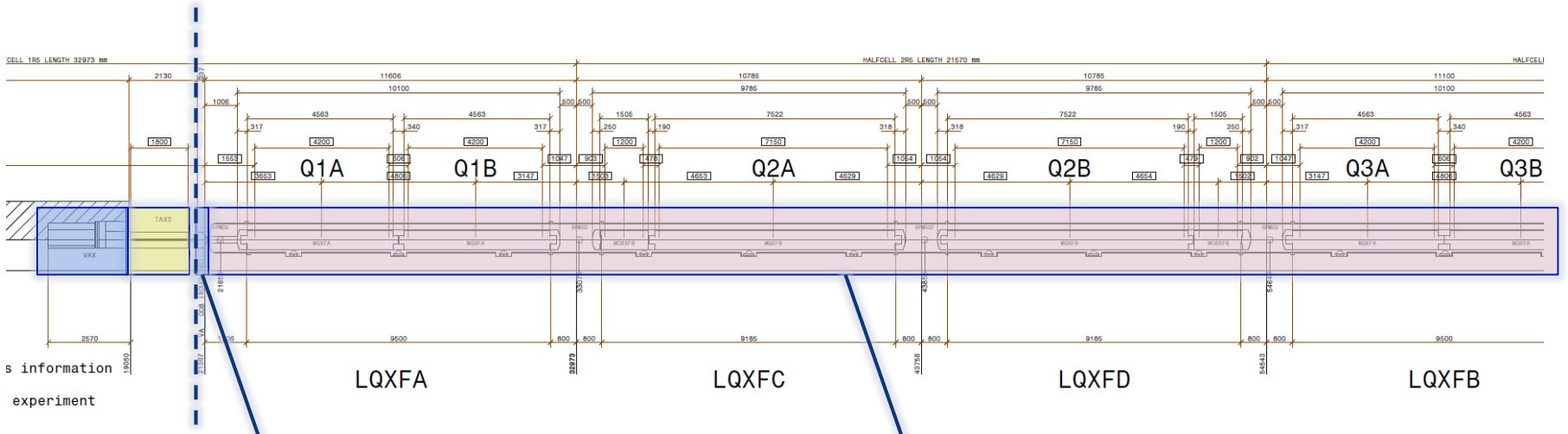
MONITORING OF THE RELATIVE POSITION

- HL-LHC





Alignment tolerances in LSS5



VSC

VA

Adjustment: ?
Determination of position: ?

Main components

Q1, Q2, Q3

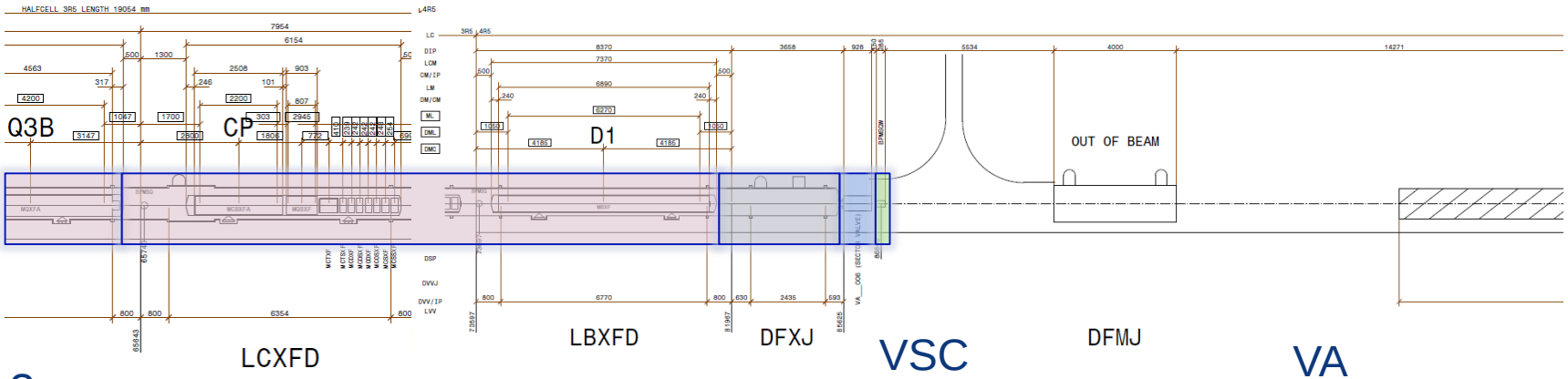
Adjustment: manual (initial alignment) : ± 10 mm (vertical, horizontal)
Adjustment: motorized: ± 5 mm in vertical, radial (resolution < 10 µm)
Determination of position: ± 0.1 mm (Q1 → Q5) (mechanical axis of the components
[Baseline]

WP8

TAXS

Current tolerances are 0.5 mm for the determination of the position and -+ 10 mm in each of the 4 support points ((two vertical and two horizontal).
The new TAXS will have similar values but due to the fact that the cavern movements are known the range could be decreased 0.5 mm and -+ 5 mm (which is better for the bellows after) [F. Sanchez Galan]

Alignment tolerances in LSS5



?

DFXJ

Alignment tolerances to be defined

VSC

VA

Two cases according to position before or after DFXJ [See VSC presentation]

Main components

Q3, CP, D1

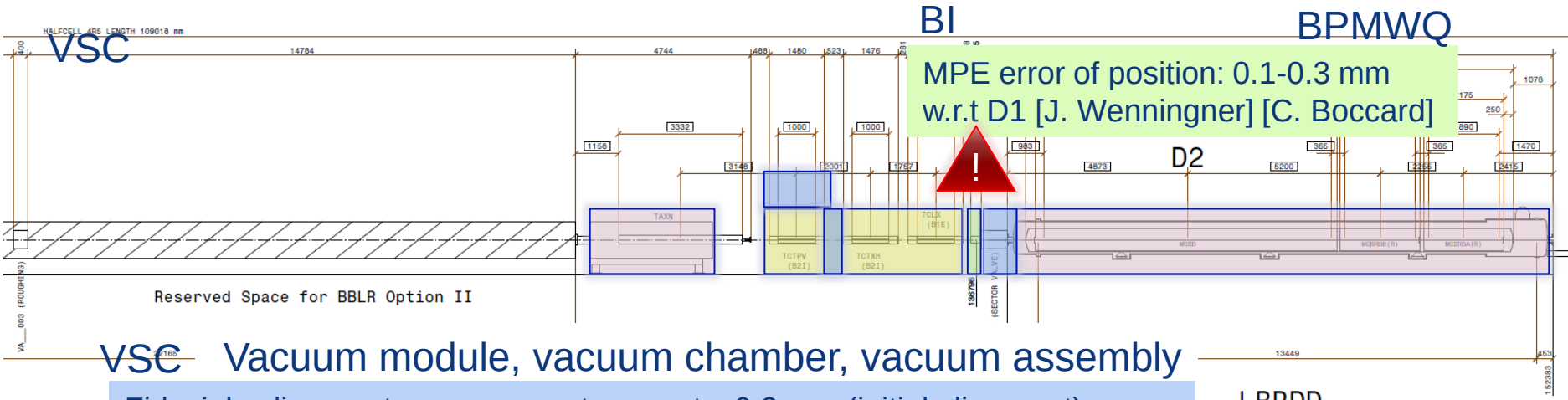
Adjustment: manual (initial alignment) : ± 10 mm (vertical, horizontal)
Adjustment: motorized: ± 5 mm in vertical, radial (resolution < 10 µm)
Determination of position: ± 0.1 mm (Q1 → Q5)
[Baseline]

BI

BPMSCW

MPE error of position: 0.1-0.3 mm w.r.t D1 [J. Wenningner] [C. Boccard]

Alignment tolerances in LSS5



VSC Vacuum module, vacuum chamber, vacuum assembly

Fiducials alignment accuracy w.r.t magnets: 0.2 mm (initial alignment)
Smoothing tolerance: 1 mm
Adjustment/exchange system to be developed by VSC
Remote determination system to be developed by SU
[See VSC presentation]

TAXN, D2

Main components

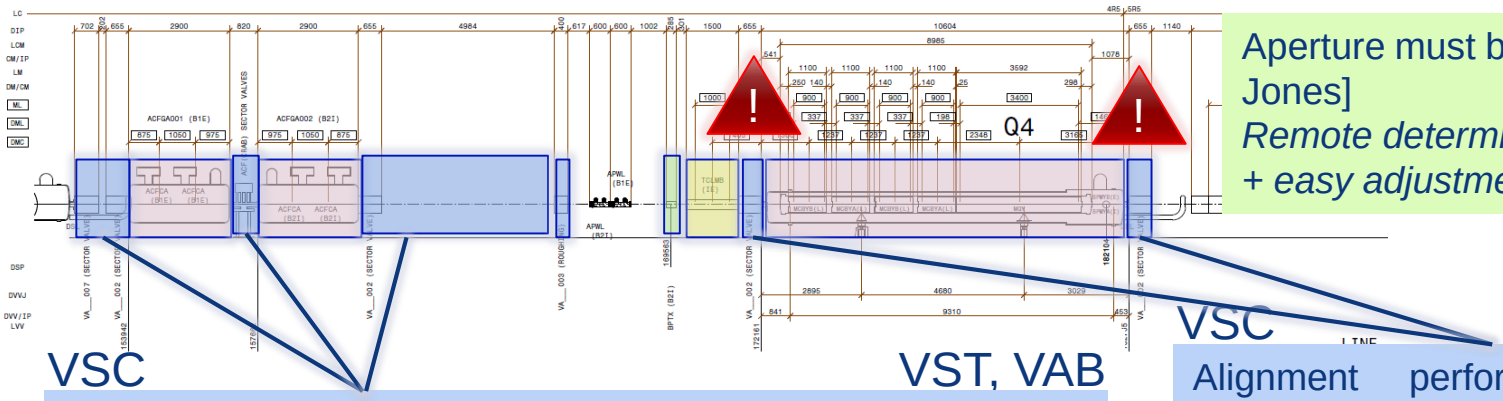
Adjustment: manual (initial alignment) : ± 10 mm (vertical, horizontal)
Adjustment: motorized: ± 5 mm in vertical, radial (resolution < 10 µm)
Determination of position: ± 0.1 mm (Q1 → Q5)
[Baseline]
Additional adjustment capabilities: CE impact

Collimators

TCTPV, TCTXH, TCLX

Same tolerances than LHC [S. Redaelli]
Fiducials position: 0.05 mrad (roll), ± 0.15 mm (1σ) over 200m w.r.t adjacent quadrupoles
Adjustment system to improve , remote measurements of targets to study

Alignment tolerances in LSS5



BI

BPTX

Aperture must be maintained [R. Jones]
Remote determination of targets + easy adjustment system ?

VSC

VST, VAB

Two scenarios for CC with ID84mm (moved or not by ± 2 mm) [See VSC presentation]

VSC

VST, VAB

Alignment performance to be checked as Q4 displaced remotely [See VSC presentation]

Fixed mask

TCTPV, TCTXN, TCLX

TAXN and fixed mask must be aligned with the magnets for protection and aperture. Only small residual of ground motion ~1 mm accounted for aperture. [R. De Maria] definitely, the masks have to be aligned with the magnet (that follows on the non-IP side). [F. Cerutti]
Same adjustment and position determination capabilities than the main components?

Main components

Crab cavities, Q4

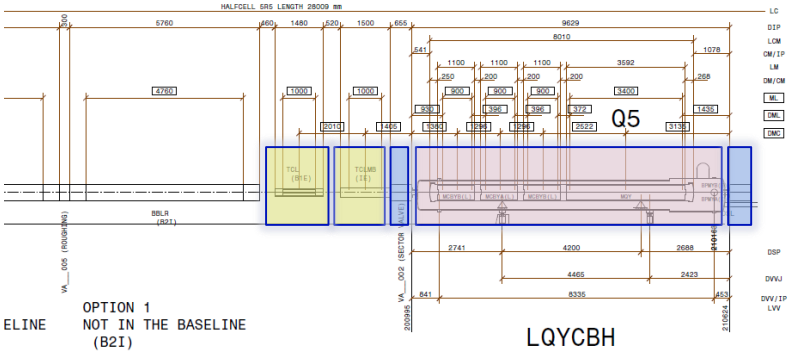
Adjustment: manual (initial alignment) : ± 10 mm (vertical, horizontal)
Adjustment: motorized: ± 5 mm in vertical, radial (resolution < 10 µm)
Determination of position: ± 0.1 mm (Q1 → Q5)
[Baseline]
Additional adjustment capabilities: CE impact

RF

APWL

Rama Calaga to be contacted

Alignment tolerances in LSS5



Shielding

TCTPV, TCTXN, TCLX

TAXN and fixed mask must be aligned with the magnets for protection and aperture. Only small residual of ground motion ~1 mm accounted for aperture. [R. De Maria]
definitely, the masks have to be aligned with the magnet (that follows on the non-IP side). [F. Cerutti]
Same adjustment and position determination capabilities than the main components?

Collimators

Same tolerances than LHC [S. Redaelli]
Fiducials position: 0.05 mrad (roll), ± 0.15 mm (1σ) over 200m w.r.t adjacent quadrupoles
Adjustment system to improve , remote measurements of targets to study

Main components

Q5

Adjustment: manual (initial alignment) : ± 10 mm (vertical, horizontal)
Adjustment: motorized: ± 5 mm in vertical, radial (resolution < 10 µm)
Determination of position: ± 0.1 mm (Q1 → Q5)
[Baseline]

VSC

VAB

Alignment performance to be checked as Q4 displaced remotely?

Case of components after Q6

- Quadrupoles & dipoles:
  - Determination of fiducials position: 1σ deviation w.r.t a smooth curve of 0.15 mm in a 150 m sliding window
  - Adjustment: ± 20 mm in vertical, ± 10 mm in horizontal

- Case of intermediary components:
  - same procedure than in the LHC w.r.t adjacent components: determination of fiducials position w.r.t adjacent components within ± 0.15 mm.

Summary

- Current issues:
  - Alignment requirements of BPMWQ in front of D2 and BPMSCW after D1 can't be achieved with the present layout
  - VAB and fixed mask around Q4 and Q5
- To be defined:
  - Aperture of BPTX
  - Tolerances of alignment of APWL
  - DFXJ case
  - VSC device in front of Q1
- To be studied by SU: a remote measurements system for the intermediary components
- To be validated by SU: the design of the intermediary components supports

Summary

- What can be achieved in a closed tunnel:

  The alignment of all the main components (continuous determination of position + remote adjustment): Q1, Q2, Q3, CP, D1, TAXN, D2, Crabs cavities cryostats, Q4, Q5

- What can be achieved during TS:

  Same than before + alignment of **intermediary components** according to **the radiation level** (only the intermediary components equipped with dedicated targets for remote determination & supported by “easy” adjustment systems)

- What can be achieved during YETS, LS:

  Same than before + all intermediary components (according to the radiation level)