



Jacks for the HL LHC magnets

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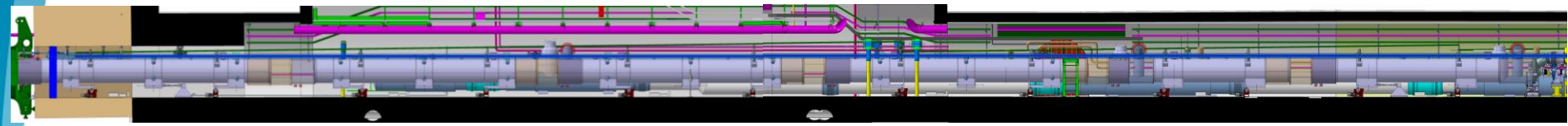
Review of HL-LHC Alignment and Internal Metrology (WP15.4)

Outline

- HL LHC jacks layout and loads
- Can the LHC triplet jacks be used?
- Design and supply strategy
- Summary

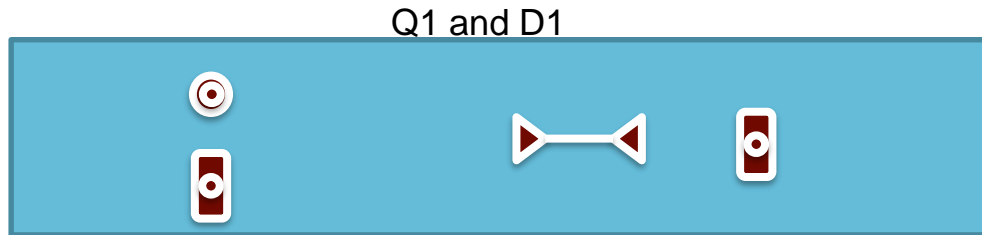
The IR cryostats (triplets-CP-D1)

Q1 Q2a Q2b Q3 CP D1



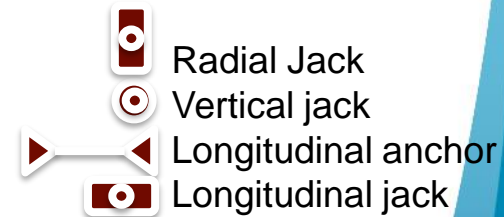
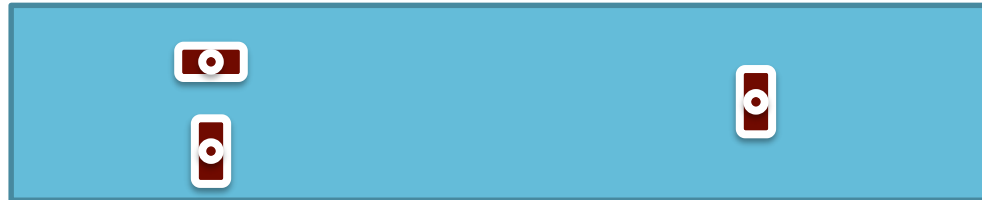
Functional layout of jacks (top view)

IP side



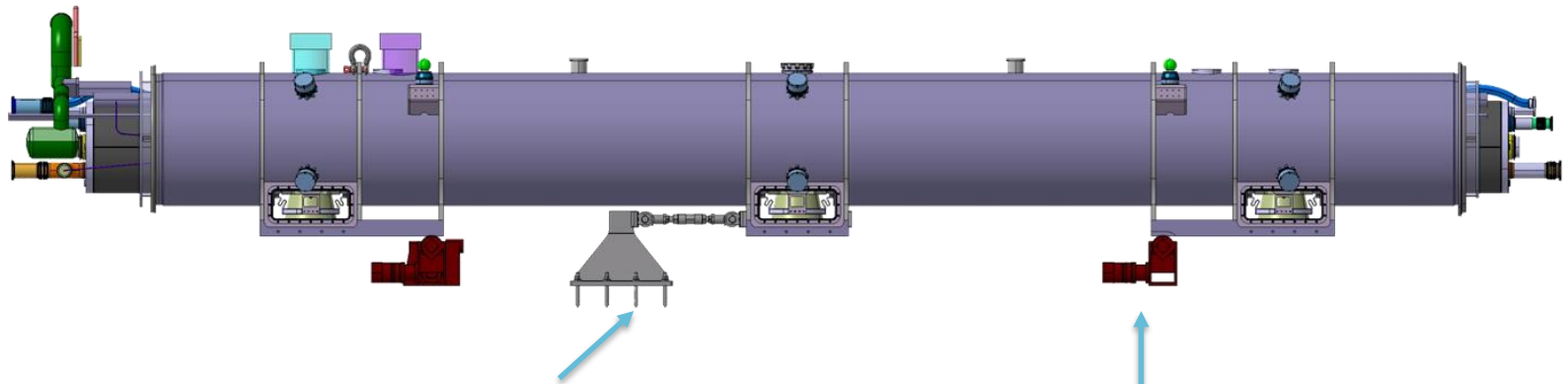
Q2a/b, Q3, CP

IP side



Note: Radial and Longitudinal jack can be the same one turned by 90°

Vacuum forces: anchor for Q1 and D1



Longitudinal anchor for Q1 and D1:
tie rod designed to hold vacuum and
quench loads (longitudinal)

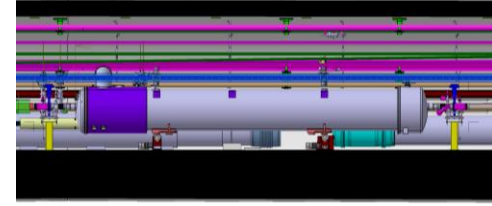
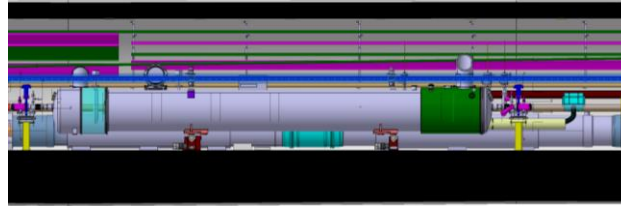
Alignment jacks on three
points (isostatic) with remote
motorized actuation

D1, Q4 and Q5

D2

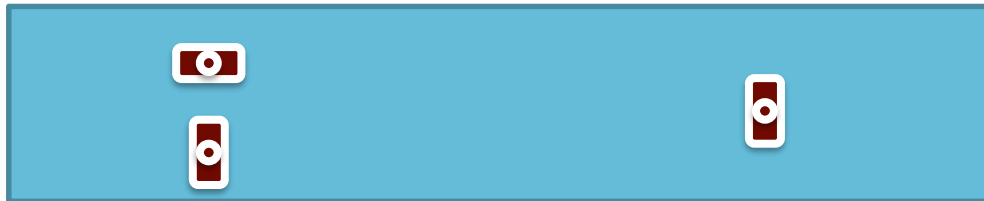
Q4

Q5

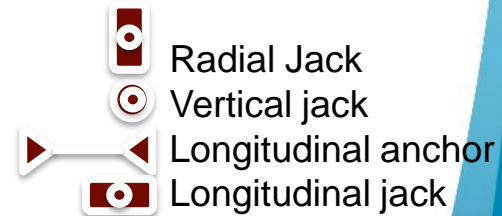
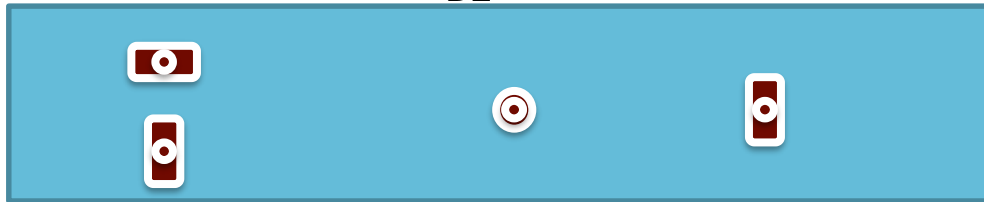


Functional layout of jacks (top view)

IP side



IP side



Note: Radial and Longitudinal jack can be the same one turned by 90°

Estimated maximum loads at jack head

Maximum loads (nominal, excluding contingency)	Radial jack	Longitudinal jack	Vertical jack	Longitudinal anchor
Longitudinal load Fy [kN]	0	27	0	LHC-HQF-ES-0001
Radial load Fx [kN]	12	0	0	0
Vertical load Fz [kN]	162	162	162	0

- Main sources of loads are:
 - Self weight of cryo-magnets
 - Interconnection and jumper bellows: pressure loads, spring reactions due to stiffness
 - Longitudinal vacuum loads is taken entirely by anchors
- Maximum HL LHC jack loads are (marginally) within the envelope of the LHC jacks, suggesting a possible use of similar jacks

Can the LHC triplet jacks be used?

- Operational issues in LHC triplets (Pt5 in particular): in some cases Survey cannot operate motorized alignment « nominally » (non-predictable vertical movements) → next slides
- Integration space requirements, due to the motorization units, do not comply with needs → next slides
- All other jack requirements (range, resolution, etc.) are being reviewed but are considered to be within those of the LHC triplet jacks

Understanding the operational issues in the LHC triplets

- As presented by Helene yesterday (see her introductory talk) there are, in some cases, unpredictable vertical adjustments when operating the alignment motors

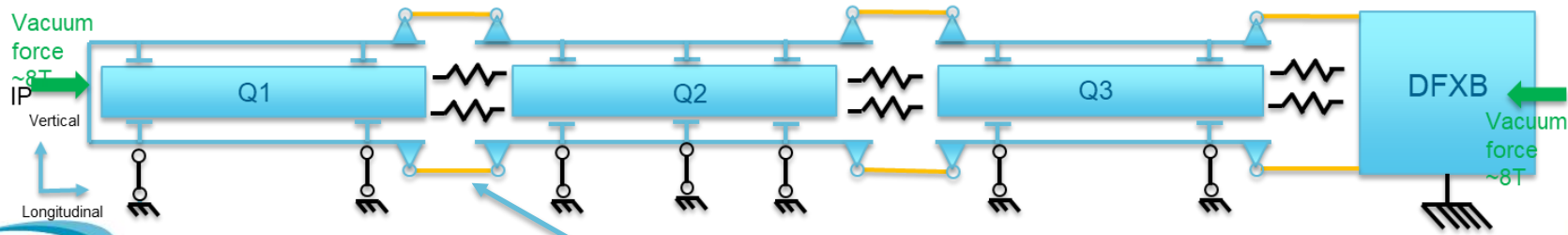
- We have been able to reproduce these uncertainties in the mock-up assembly in Bd.181, suggesting that this is the result of friction forces occurring when the jacks are operating beyond their longitudinal range

- The end of range movements are the consequence of having too high flexibility in the tie rods restraining the longitudinal vacuum force across the interconnections

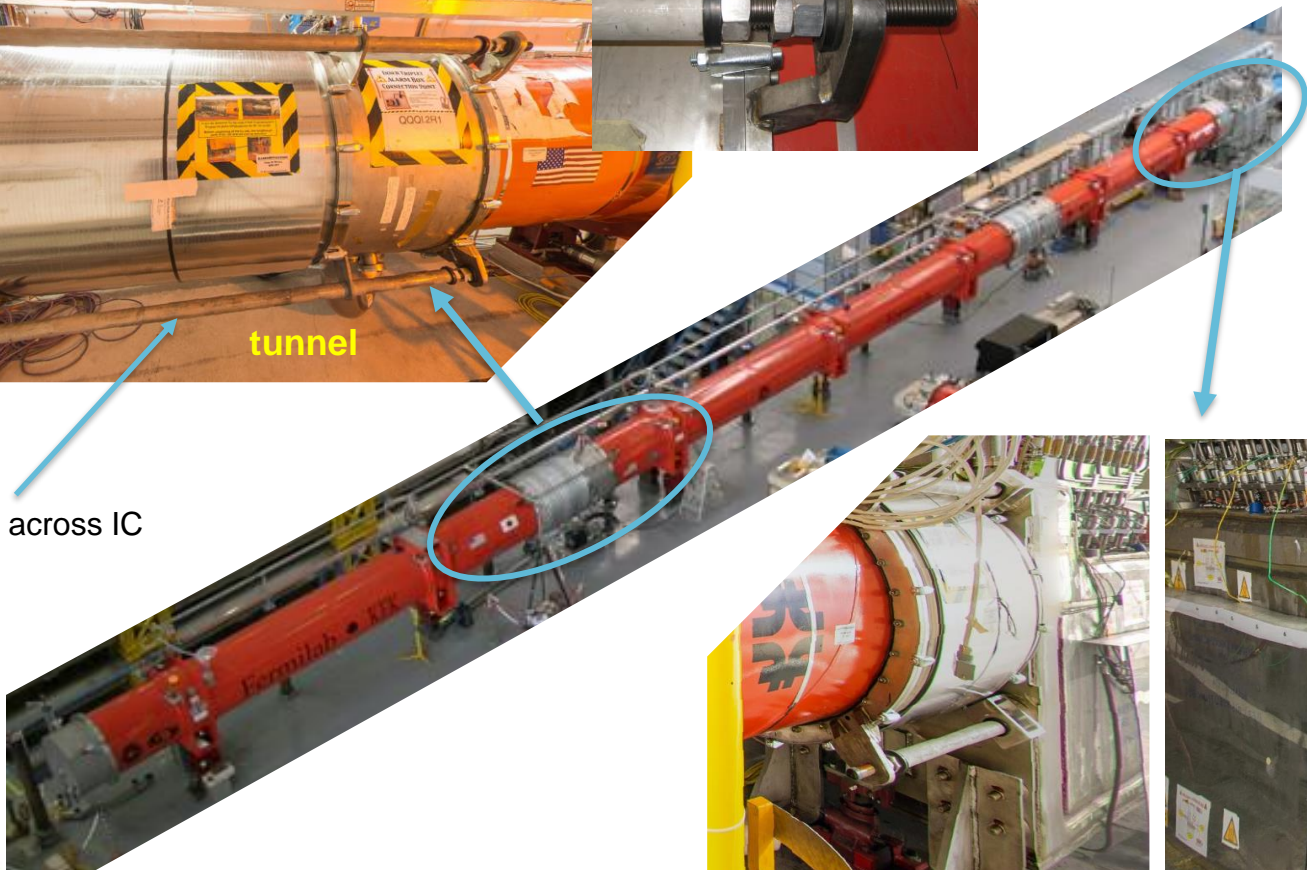
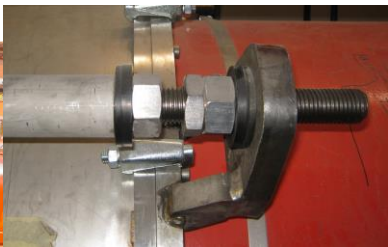
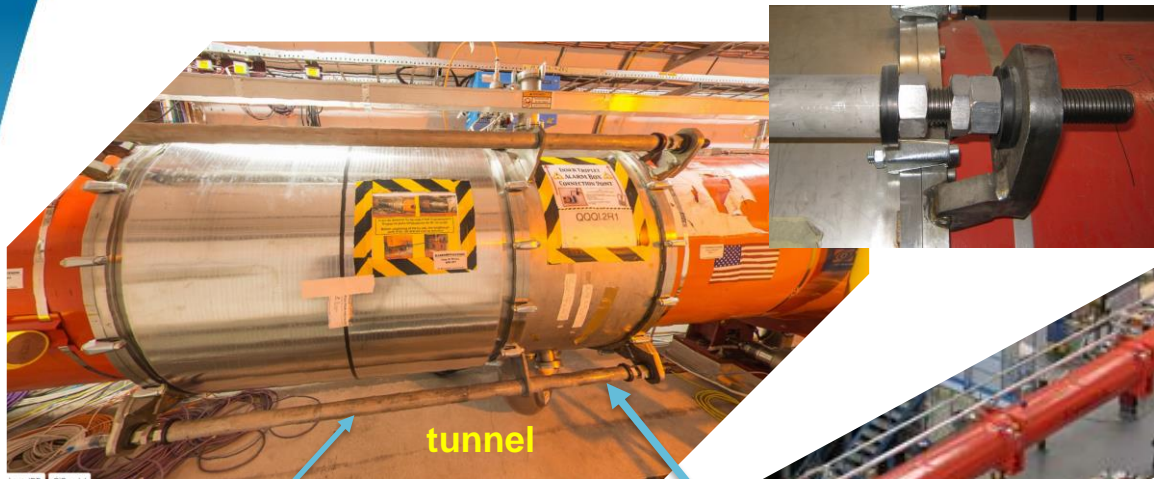
- In the HL LHC layout, vacuum forces will be taken by anchors, so the jacks will not be operating beyond their longitudinal range



Non-IP

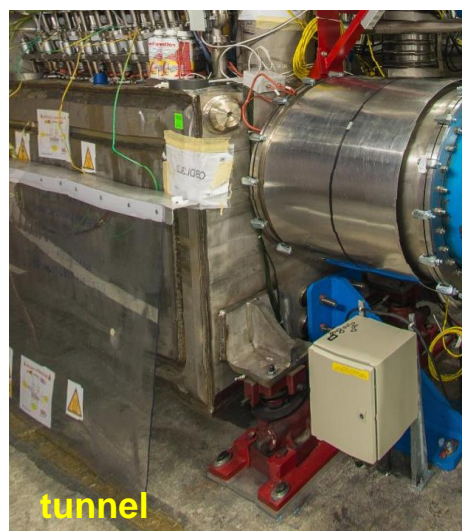
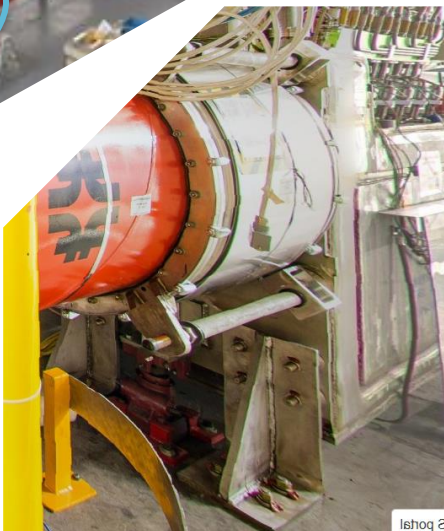


Tie rods across IC



tunnel

Tie rods across IC

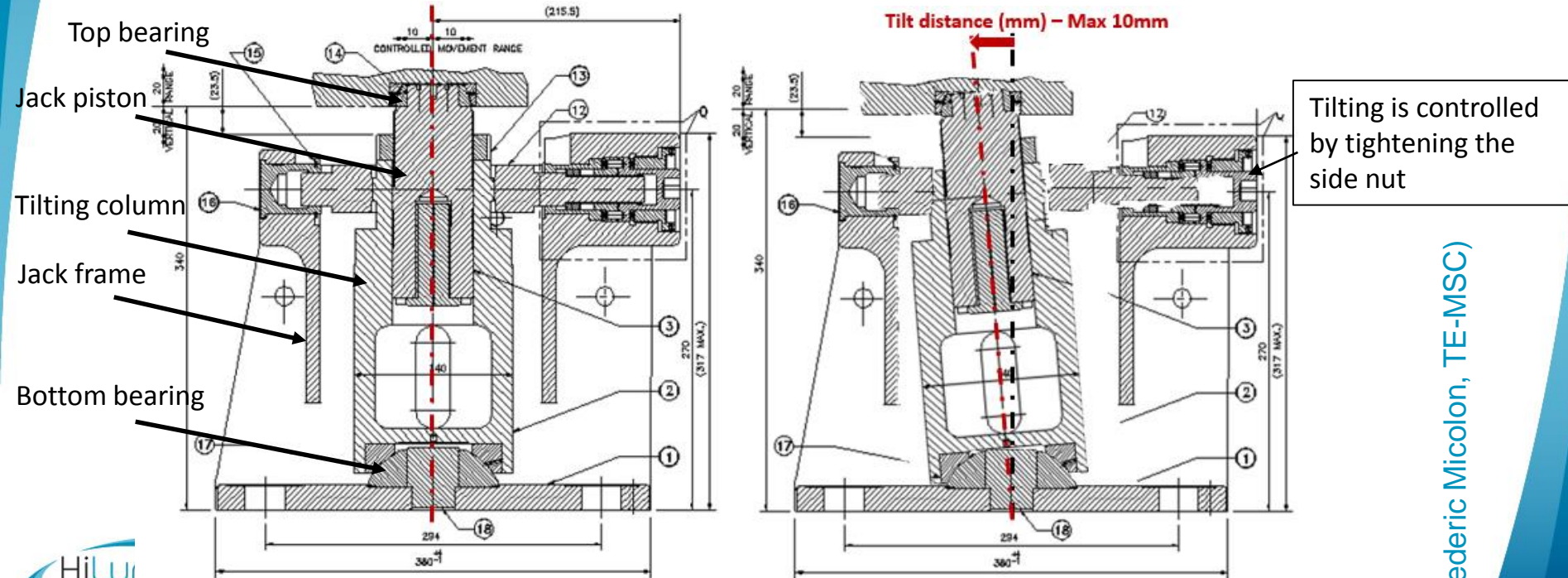


tunnel

Ishoq 2

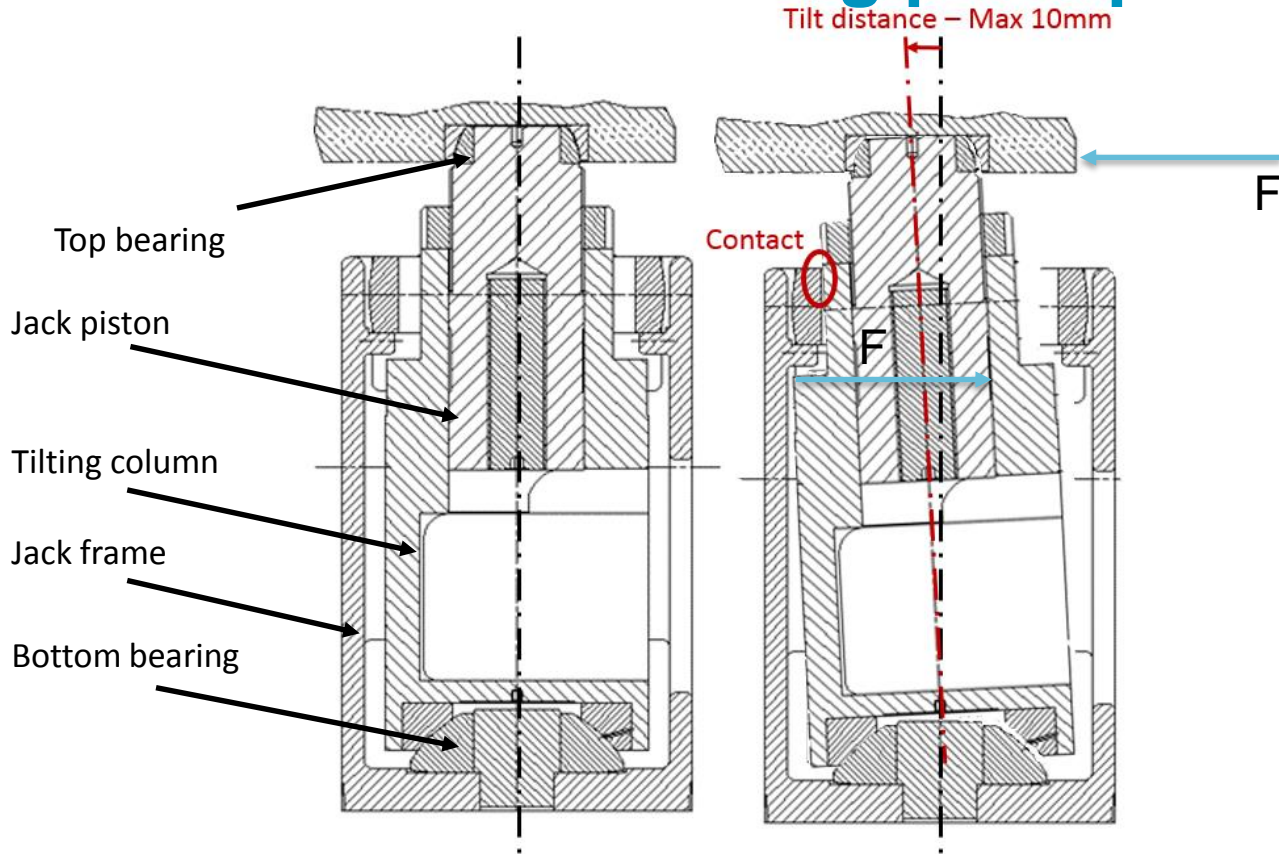
The LHC Jacks working principles

The LHC jacks is based on a tilting column principle – with two bearing on each end. It allows the position control in the vertical direction and one transverse direction (the other transverse direction is free by design – see next slide).



In the LHC triplets, the side nut is removed. So this becomes a free transverse direction (no control).

The LHC Jacks working principles

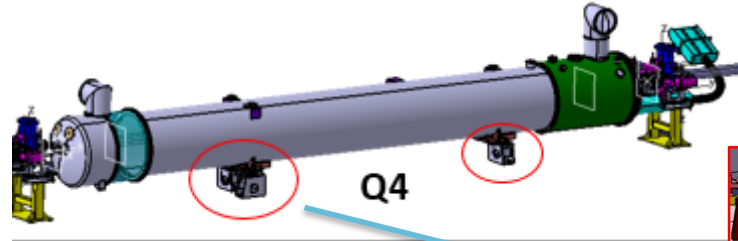


This transverse direction is free by design with a range of $\pm 10\text{mm}$. Beyond this limit, the contact creates reaction forces (F) with friction interfering with vertical movement which the system was not designed for.

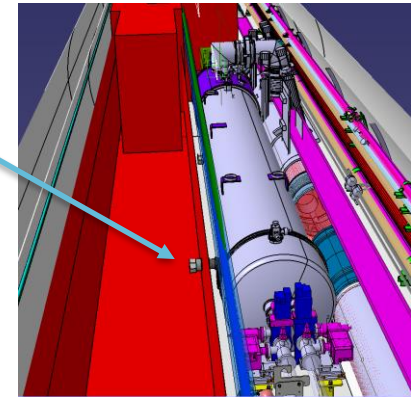
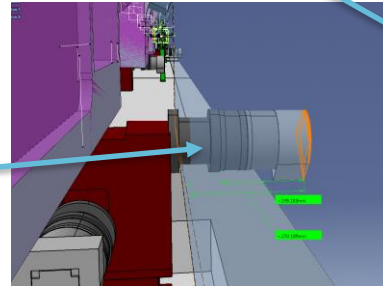
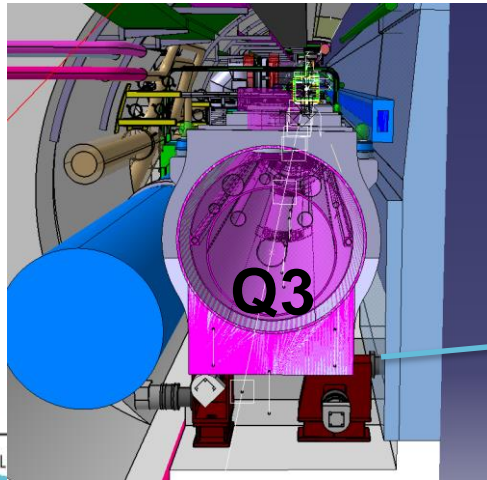
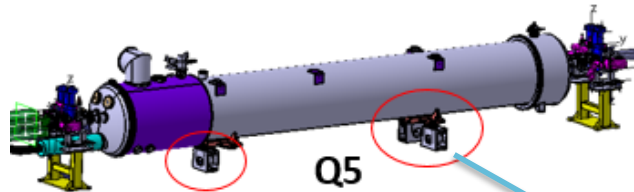
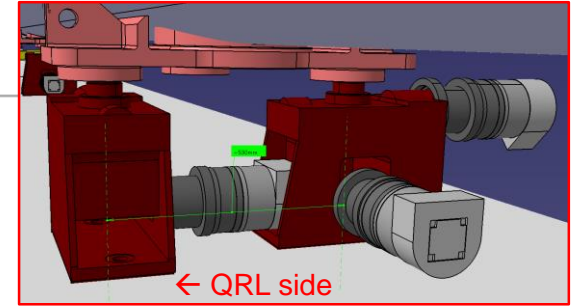
Integration space requirements issues

Interference of motorization units:

- Interference with transport zone: Q4, Q5, D2, triplets
- Q4: also interference under cryostat



5R



(Integration study: courtesy of M.Amparo, EN-MME, under WP15)

Design strategy

Important facts:

- Operational issues on present triplets seem to be understood not precluding the use of similar jacks for the HL LHC
- Survey is interested in capitalising on the operational experience of remote motorised alignment from LHC, so would be favourable in making use of similar jacks
- A new integrated design of the motorization units and the jacks must be done to comply with tunnel space integration
- There is also an (obvious) interest to try and standardise the jacks for «non-magnet» HL LHC applications: Crabs, TAXN. This is certainly possible provided the project engineers in charge of these equipment confirm that the jacks comply with their needs (space requirements, loads, ranges, etc.)

Design strategy (cont.d)

- The (re)engineering of the HL LHC magnet jacks is to start in September («job» with EN-MME is in preparation)
- Input specifications for an « integrated design » of jack and motorization:
 - For the magnets: TE-MS/CMI (D.Ramos)
 - For the motorization: EN-SMM
- Main design steps:
 - Finalise specs: by Oct. '19
 - Design: by mid '20
 - Pre-series for qualification in String (18 units + 2 spares): mid '21
 - Production of series (108 units +10 spares)
- Exploring one «motorized jack for all seasons » needs input specifications :
 - For Crabs (WP04), 24 units: EN-MME
 - For TAXN (WP5), 12 units: EN-EA
- Total scope of procurement: 20 pre-series (String) + 154 series: 174 jacks

Procurement strategy

- HL LHC supports a procurement through an in-kind contribution
- Republic of Serbia has expressed an interest for a full in-kind contribution. First discussions have taken place.
- CERN EN-SMM prefers to keep the motorization units as in-house supplies (for reasons of standardization of driver electronics), so it is preferable to engineer a new motorization unit + jack at CERN (solving the space integration aspects *inter alia*)
- Hand over the production of the jacks to Serbia based on build-to-print:
 - Qualify design/pre-series over 20 units for the String
 - Production of series to follow for LS3

Summary

- The HL LHC magnets needs about 140 jacks (up to 174 if we add units for Crabs and TAXN)
- Operational issues on present LHC triplets seem to be understood, therefore does not preclude using the same working principles for the HL LHC jacks
- The HL LHC jacks can be derived versions of the LHC jacks to integrate new motorisation units compatible with space requirements
- The (re)engineering of the HL LHC magnet jacks is to start now, aiming at a design in 2020 for pre-series jacks to be validated on the String
- The present procurement strategy is to have an in-kind contribution from Serbia



Thank you