Full Remote Alignment Study (FRAS) And Matching Section Optimization Targets, and advancement report

FRAS: M. Amparo (WP15.1),R. De Maria (WP2) L. Funder (WP12), **J. Hansen (WP12), A. Herty (WP15.4),** R. Tavares Rego (WP12), with the external support of L. Gentini (WP5)

Matching Section Optimization : all WP leaders, D. Duarte Ramos (WP3), H. Prin (WP3), Y. Leclercq (WP6A), M. Sisti (WP9)

Coordination: S. Claudet, P. Fessia

Summary

- The target for the Full Remote Alignment Study
- The target for the Matching Section Optimization
- Where we are for the Full Remote Alignment Study
- Where we are for the Matching Section Optimization

Very limited technical details
More extensive technical presentations to be planned in a second moment

Full Remote Alignment Study

- Perform an initial analysis in order to identify which are the best options to effectively remotely align the LSS components. This includes the analysis of possible coupling of different components/systems on the same aligning support
- Prepare the required data and information in order to support WP12 in the proposal of an optimized (technically and cost wise) vacuum lay-out
- Push for the standardization of the adopted aligning solutions

Status of the FRAS

From April to June 2018, most of the stakeholders have been invited to meetings:

- Collimators: section TCTPV, TCTPXH and TCLX
  Luca Gentini, Inigo Lamas Garcia, Alessandro Bertarelli
- Beam Instrumentation: BPWWQ as example of alignment needs
  Gerhard Schneider, Jorg Wenninger
- Masks: TCLMB's in front of Q4 and Q5
  Francesco Cerutti
- Crab Cavities: crab cavities and adjacent vacuum equipment
  Teddy Capelli

Proposals for these zones have been discussed with the WPs. Other proposals have not been presented in detail to the WPs.

The interface TAXS – Q1 will be discussed with the WP beginning of July 2018.

Francisco Sanchez Galan

Courtesy of FRAS team

Alignment Scenario

- First year of operation would require
  - Correction by remote alignment after initial luminosity to compensate for potential large IP offset because of the experiment/machine assembly incertitude
  - Correction to human intervention in the tunnel at first YETS to recover the full 2.5 mm of remote alignment capacity
- From year two ground motion is compensated on an annual basis (or in the zones potentially affected by the HL CE more often if needed)
- Man intervention in the tunnel shall be limited at the LSs to recover the full 2.5 mm remote alignment stroke wherever possible. Location where this is not possible still to be analyzed

Alignment strategy

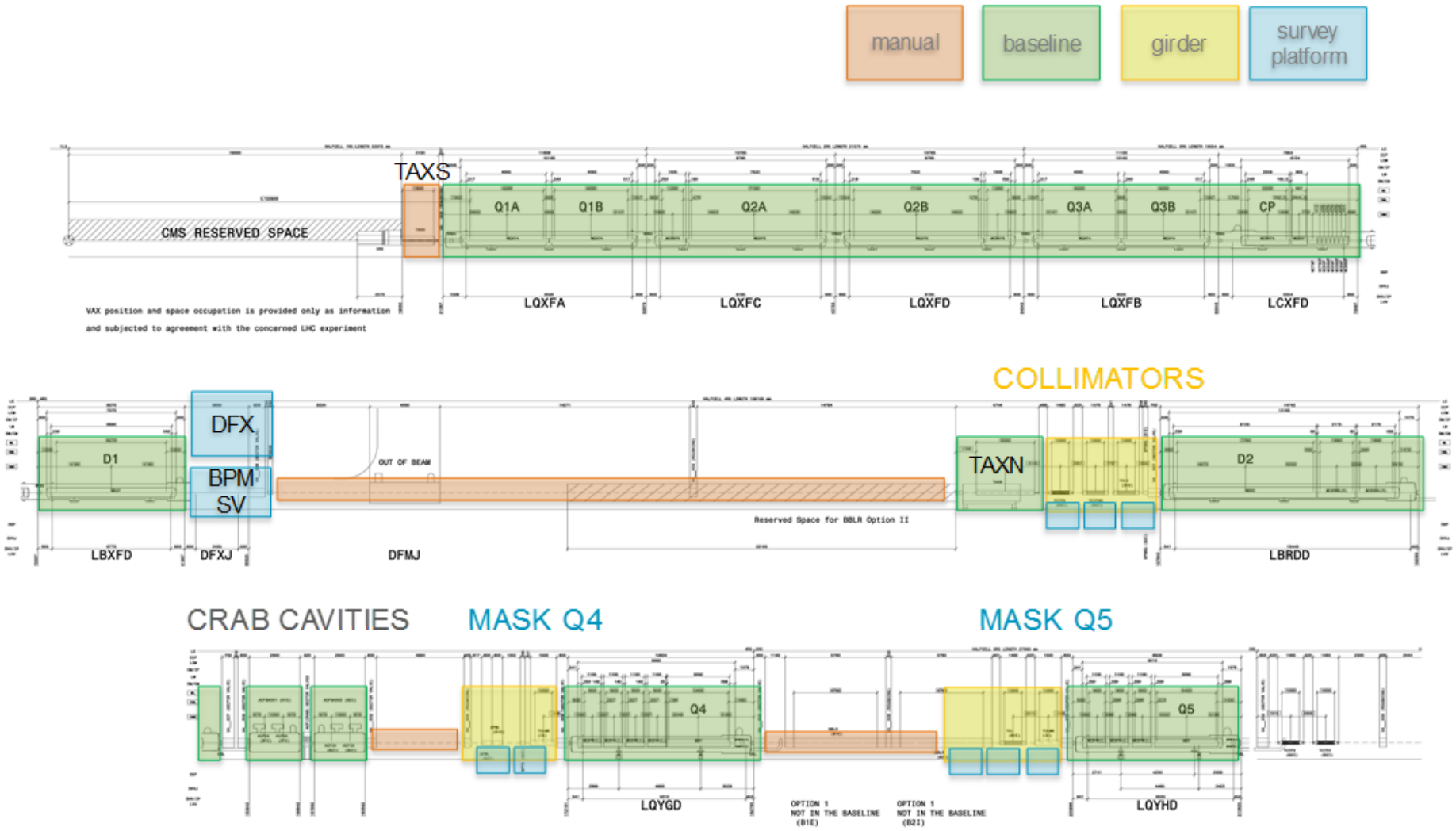
- Ground motion is corrected individually to the components or on groups
- Local ground motion (approx. 10 m zone) will roughly be the same, thus girder options can be considered
- In case an IP shift is needed, all components of the LSS are shifted from Q1 to Q4 by the amount needed.

HiLumi HL-LHC PROJECT

CERN

Courtesy of FRAS team

A possible approach in scheme



Components for a Full Remote Alignment (I)

The FRAS takes into account in the proposals that

- The baseline foresees the alignment of main components with motorised jacks and appropriate monitoring sensors. This baseline design has not been changed.
- The TAXS is considered to be aligned manually with the given radiation level in the TAXS area
- Platforms that are under development by WP15.4 shall be considered as the standard interface for alignment purposes, providing
  - The option of a manual alignment of the platform with the interface screws facing towards the corridor side of the tunnel;
  - Can be “upgraded” without modification for a plug-in alignment. Temporary motors and relative displacement sensors can be used for the alignment or
  - Resident motors and sensors can be installed to remotely align the platform.
  - The platforms will be designed in a light weight (up to 500 kg) and a heavy duty platform (up to approx. 2000 kg)
  - WP15.4 will provide a validated conceptual design to be integrated by each equipment owner

Courtesy of FRAS team

Components for a Full Remote Alignment (II)

- Girders can provide a solution for combining several components on one platform that have to follow a common alignment strategy.
- The choice of the alignment strategy (element with limited differential movement among them) has an impact on the vacuum lay-out design. In particular the use of standard RF bridges or deformable RF bridges.

Starting from end of June we are now escalating to a new level where on the base of the previous discussion we involve WP leader and main stakeholders in order pass to the implementation involving resource allocations, baseline and budget changes

Courtesy of FRAS team

WP by WP observations and ongoing actions for remote alignment

- WP4:
  - A meeting with the WP4 stakeholders has taken place on the 25/07/2018
  - WP4 has agreed on the concept of embarking the vacuum components between the 2 crab cavities on one of the cryo-modules
  - Detailed technical solution has to be developed
  - We agreed to collect possible WP4 cost variations for this for end of August mid of September

WP by WP observations and ongoing actions for remote alignment

- WP5:
  - Remote alignment introduction makes possible the reduction of the tolerances required for the collimators between TAXN and D2. The gains promised by the remote alignment allow to simplify considerably the design of the new IR collimators and was supported by WP5 (See ColUSM https://indico.cern.ch/event/699355/)
  - The opportunity of having pumps, BPM or other smaller equipment embarked on the collimator supports has been discussed with WP5 and it is being taken into serious considerations and it is pushed by the remote alignment team
  - Present concept it is the adoption of the alignment platform technology as part of the design of the collimator support
    - The technical analysis of such options has still to be carried out
    - As WP15.4 (and EN-SMM for applications beyond HL) are favorable to push the adoption of standardized solutions
  - The possibility to couple together rigidly 2 or more collimators (assembling them on the same alignment support) has been put on the table, but it has to be checked vs required functionality of the system. There concerns taking into account the needs of individual alignment of each collimators
  - After the initial informal meeting between FRAS and members of the WP5 a 1st meeting with all WP5 stakeholders has taken place on the 27/07/2018 and it will be followed by a more technical meeting on the 09/08/2018
  - The agreed target is to arrive with a baseline (at least at conceptual solutions) and related cost variance for mid September

WP by WP observations and ongoing actions for remote alignment

- WP8-experimental beam vacuum:
  - It is important to validate that the proposed alignment strategy fits
    - The design of the beam vacuum between TAXS L and TAXS R through the IP
    - The new VAC requirements
    - The upcoming modification of the detectors
- A first meeting with the experimental vacuum team has taken place on the 24/07/2018. At preliminary discussion indicates no evident showstoppers
- A joint WP8 and WP15 meeting will be organized on the 21st of August to go more in the details and to discuss also with the experiments and more in details with the responsibles for the experimental beam vacuum

WP by WP observations and ongoing actions for remote alignment

- WP12
  - We need to start building a matrix with the max differential displacement location by location (according to the strategy that will adopted to group equipment among them)
  - We need to verify that the beam aperture is such that will accept the ± 2.5 mm displacement in the area where we do not want to move components
  - We need converge on an optimized vacuum lay-out
  - We need to see what would be the gain if we move from ±2.5 mm IP correction to ±2 mm IP correction

Matching Section optimization
or
back to the origin

EDMS No. 1976371

Coordination of the final optimization of the Matching Section layout

Mandate

The Matching Section (MS) layout of the HL-LHC IR1 and IR5 underwent a major reconfiguration during the re-baselining exercise in July 2016. Recently, a study led by P. Fessia, revealed a discrepancy in the cost variance assumed in 2016, see EDMS 1882077. Following recent information, new options have emerged:

1. The possibility of full remote alignment, allowing a reduction of the number of corrector magnets, entailing changes in the Q4/Q5, that is almost compatible with the present LHC configuration and might require much less changes than the present HL-LHC baseline;

2. The decision to eliminate the options of the second set of crab cavities and larger Q4 (MQYY), thus no longer requiring to maintain the layouts compatible with these options;

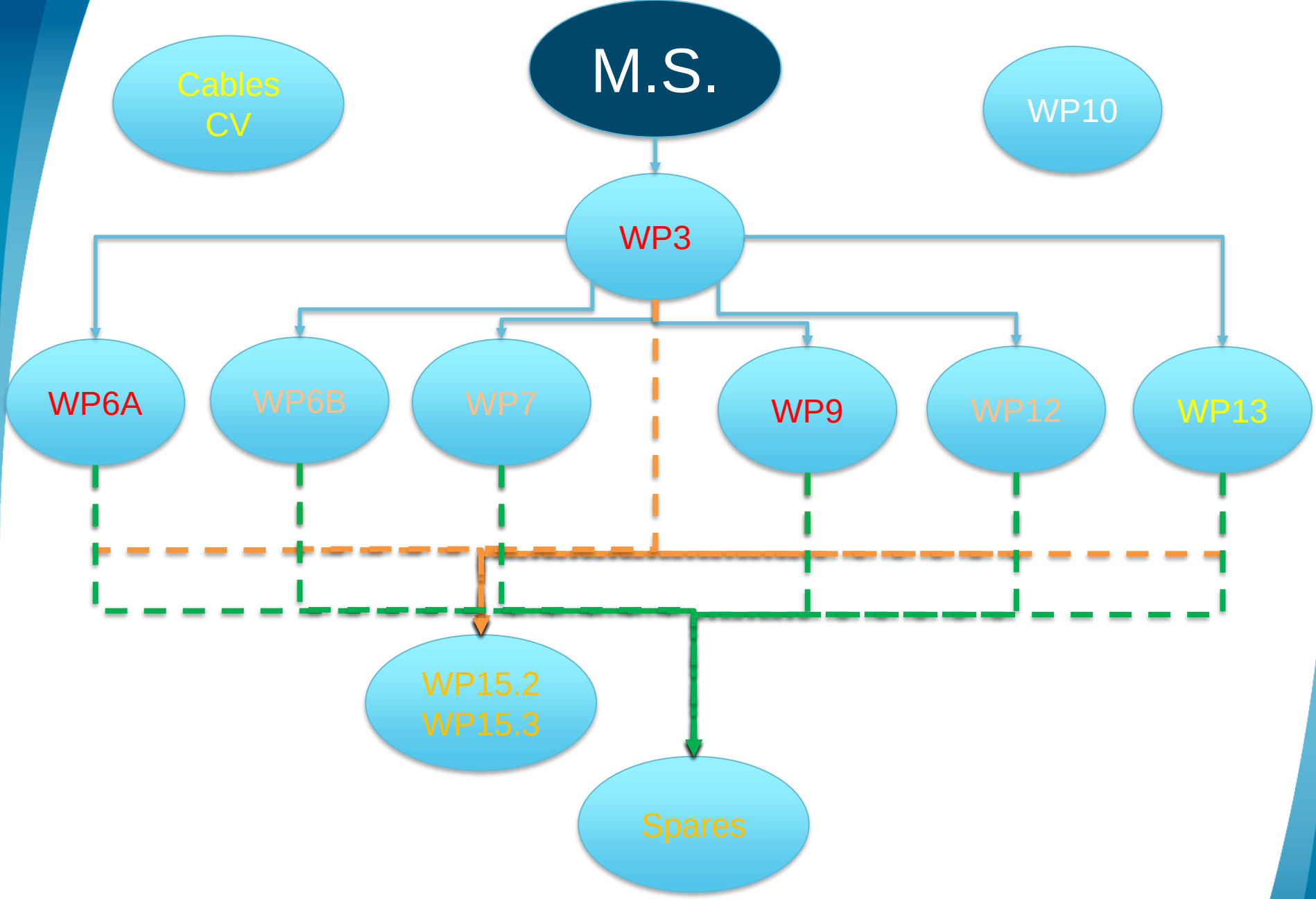
3. The possibility of powering the MS magnets with the full reuse of present LHC equipment;

4. The possibility of modifying the operating temperature of Q4/Q5 and cryogenic distribution in the MS, again with the goal of maximizing the reuse of present LHC equipment.

These and other elements call for a general re-optimization of the whole MS layout, with a careful balance between savings (reduction of new magnets and cryogenic equipment) and expenditures (new full remote alignment system, allowing a beam-based alignment).

Modus operandi

The coordinators will work with the WPLs involved, with Mr. Circuit, the HL Budget officer and the relevant service providers, to find the best optimization with an analysis of the technical and economic impact of each solution. The ease of operation and the impact on the machine availability are among the various elements of the assessment.


M.S.
Cables CV
WP10
WP3
WP6A
WP6B
WP7
WP9
WP12
WP13
WP15.2 WP15.3
Spares

How we are proceeding

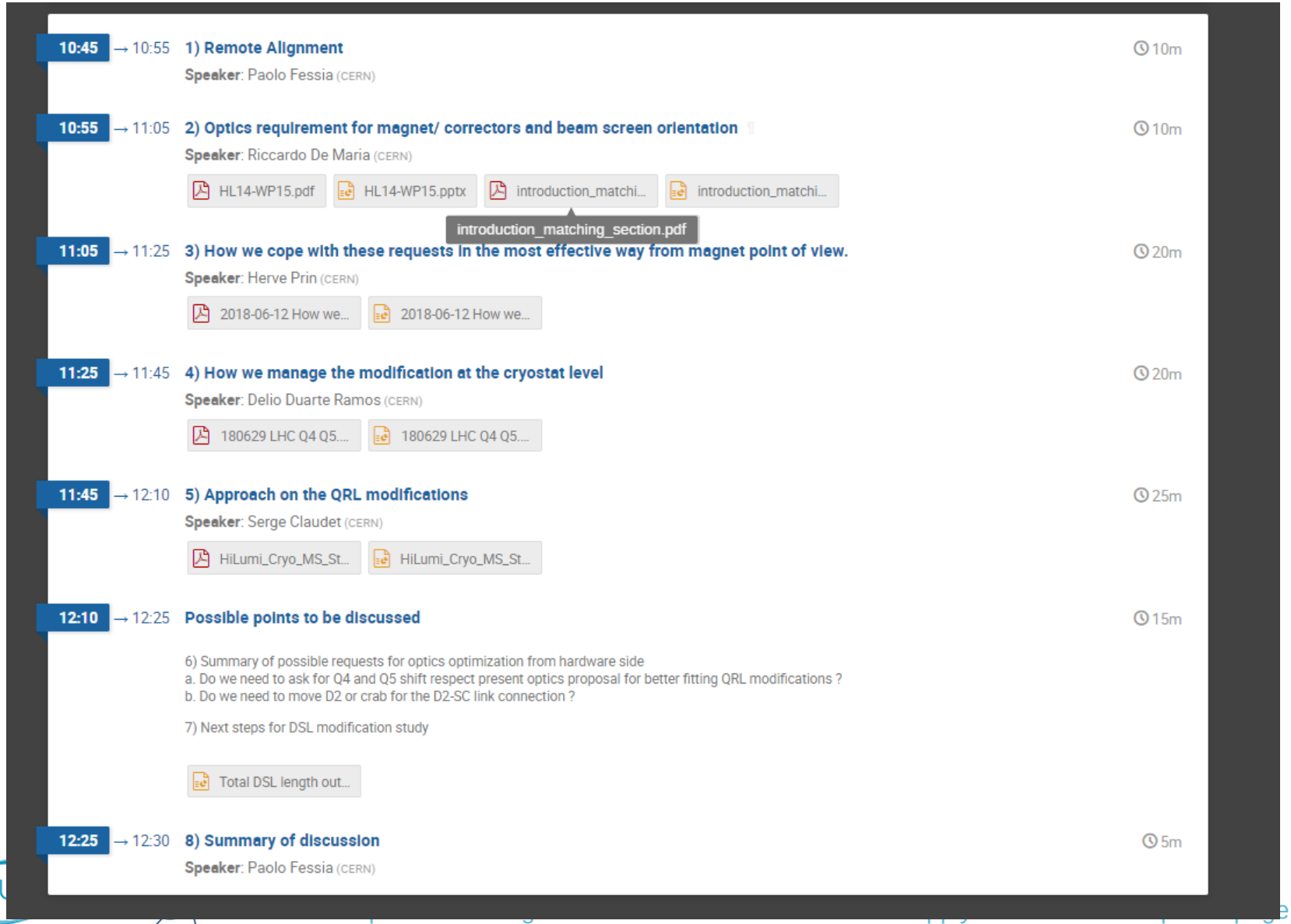
- WPs where detailed technical analysis was launched straight ahead in restricted meeting with the key-players
  - WP3
  - WP6B
  - WP7
  - WP9

- WPs where we had preparatory discussion on the approach but where options where pending from the ones above
  - WP6A

- WP not yet met or pending on results from others
  - WP12
  - WP 15.2 15.3
  - WP13
  - *Spares*
  - *Cable and CV*

For the technical details mainly of for WP3 and WP9 see
https://indico.cern.ch/event/739858/
And EDMS **1998201**

29/06/2018 meeting to fix choices for WP3 WP6B WP7 WP9



10:45 → 10:55 **1) Remote Alignment** 10m

Speaker: Paolo Fessia (CERN)

10:55 → 11:05 **2) Optics requirement for magnet/ correctors and beam screen orientation** 10m

Speaker: Riccardo De Maria (CERN)

HL14-WP15.pdf | HL14-WP15.pptx | introduction_matchi... | introduction_matchi...

introduction_matching_section.pdf

11:05 → 11:25 **3) How we cope with these requests in the most effective way from magnet point of view.** 20m

Speaker: Herve Prin (CERN)

2018-06-12 How we... | 2018-06-12 How we...

11:25 → 11:45 **4) How we manage the modification at the cryostat level** 20m

Speaker: Delio Duarte Ramos (CERN)

180629 LHC Q4 Q5.... | 180629 LHC Q4 Q5....

11:45 → 12:10 **5) Approach on the QRL modifications** 25m

Speaker: Serge Claudet (CERN)

HiLumi_Cryo_MS_St... | HiLumi_Cryo_MS_St...

12:10 → 12:25 **Possible points to be discussed** 15m

6) Summary of possible requests for optics optimization from hardware side
a. Do we need to ask for Q4 and Q5 shift respect present optics proposal for better fitting QRL modifications ?
b. Do we need to move D2 or crab for the D2-SC link connection ?

7) Next steps for DSL modification study

Total DSL length out...

12:25 → 12:30 **8) Summary of discussion** 5m

Speaker: Paolo Fessia (CERN)

Q5 Left and Right in IR1&5

- Moved by about 11m towards the DS
- Polarity remain the same
- Correctors have to act in the same plane
- Both beam screens rotated by 90º
- Temperature remains 4.5K

⇨ Jumper height to be checked if the QRL changes

⇨ **Q5 will be reinstalled at their current location after beam screen rotation on surface**

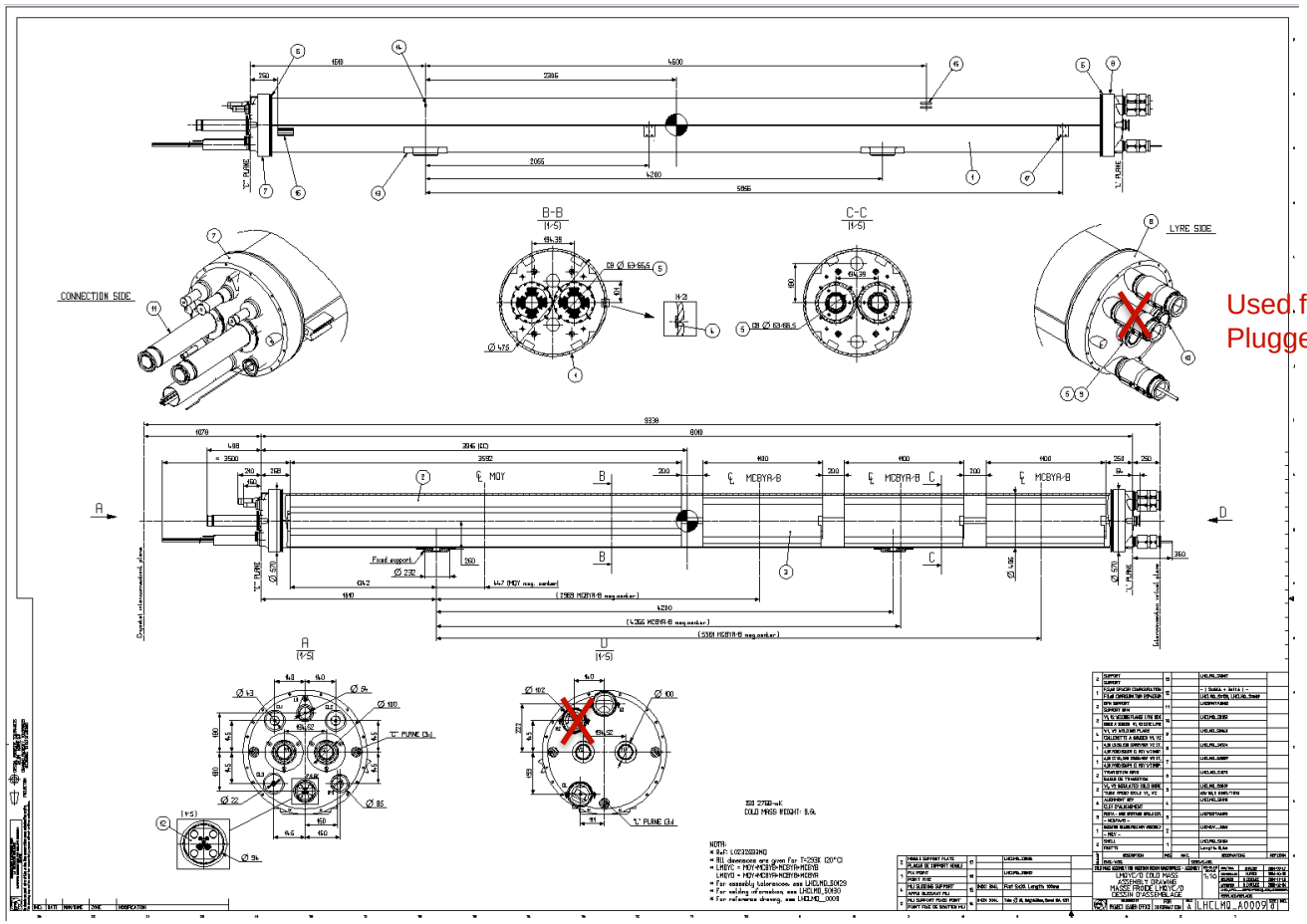
Courtesy H. Prin

Q4 Left and Right in IR1&5

- Moved by about 10m towards the DS
- Polarity remain the same
- All correctors have to act in the perpendicular planes
- Correctors positions better in the IP side
- One beam screen rotated by 90º (VV⇨HV)
- Temperature remains 4.5K
- Cryogenic distribution to be adapted (Semi-standalone ⇨ Standalone)

Courtesy H. Prin

Q4 Cold Mass Design

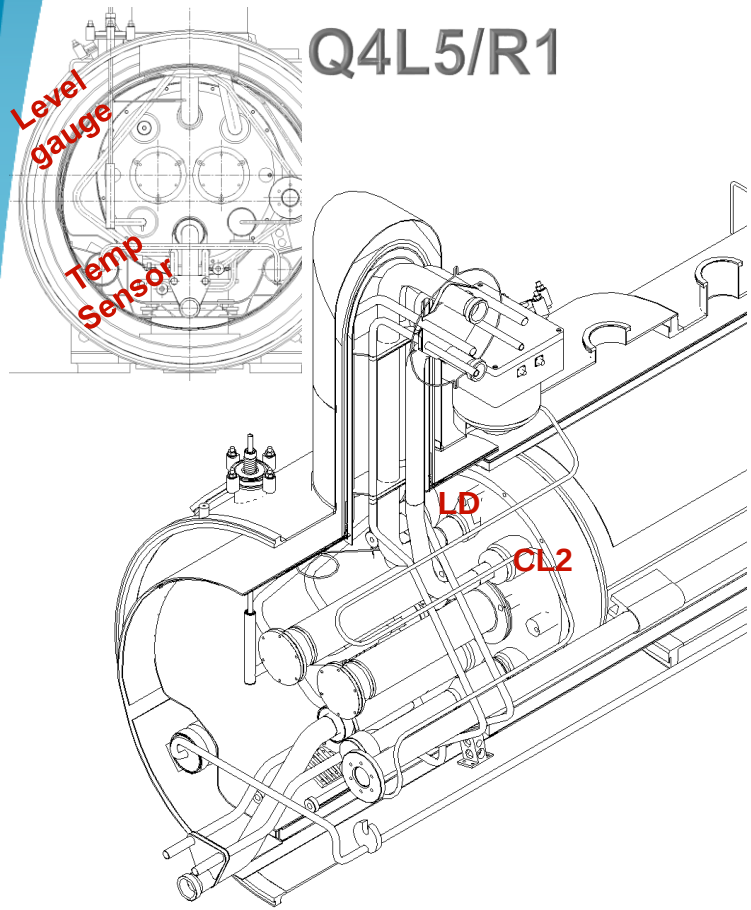


Used for the cold tests
Plugged after

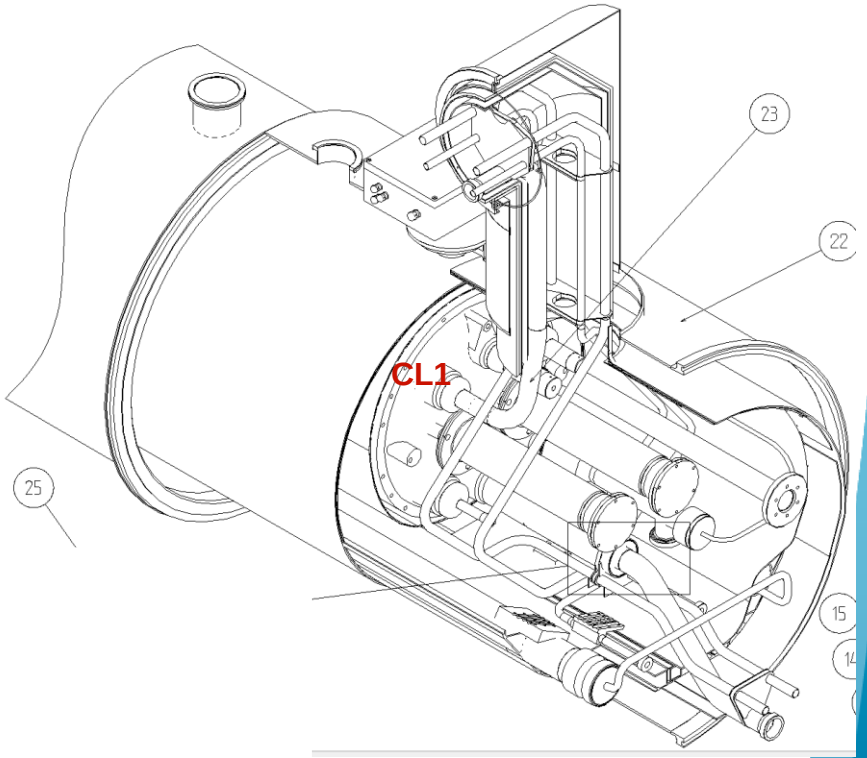
Courtesy H. Prin

Cold Mass integrated in its cryostat

Q4L5/R1



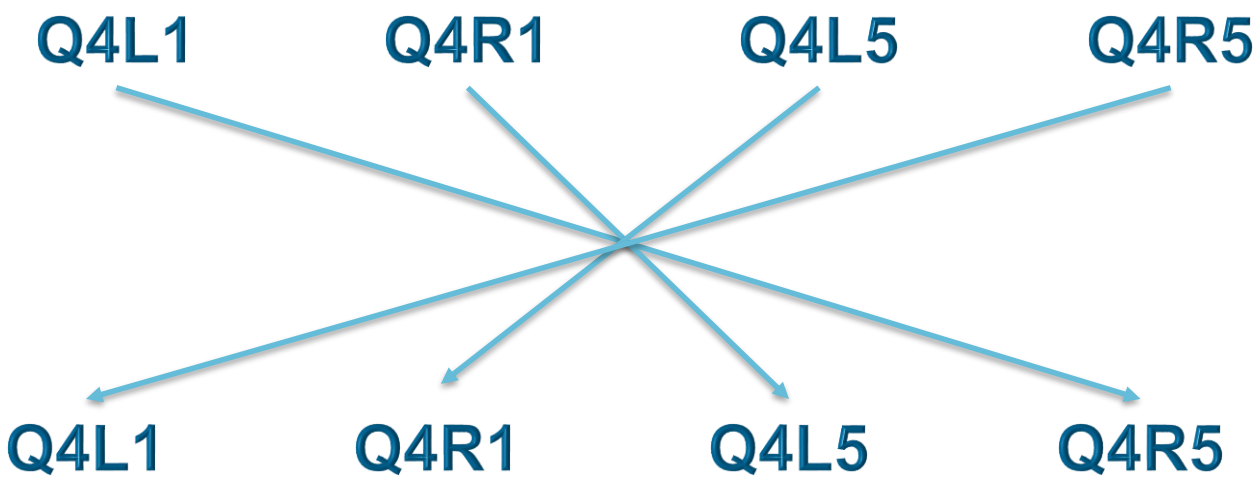
Q4L1/R5



Courtesy H. Prin

Q4 installation scheme

HL-LHC LHC



⇨ Level gauges and Temp sensors in the highest side

Courtesy H. Prin

Q4

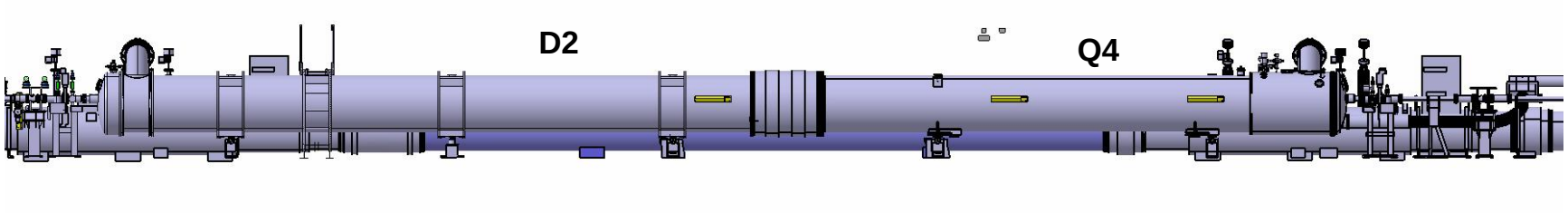
- Convert Q4 from a semi-stand alone to a stand-alone
  - Integrate D2 cryo lines into a second service module and jumper on the other Q4 extremity
    - Double jumper stiffness and impact on alignment: not expected to be an issue
    - Exposure to radiation?
    - Extra length: impact on beam vacuum / longer beam screen?
    - Thermal displacement at new jumper of 19 mm: should be manageable
    - New service module on moveable flange side:
      - Bolted sealing: trapped seals which must be cut and glued in situ. Forces from jumper may require mode clamps. Or
      - Welding: welding design to be developped
  - Add level gauge and temperature transmitter to 1L and 5R, either on existing jumper or new jumper.

- Invert the position of the correctors with respect to the quadrupole, and A) without opening the existing cold masses and B) keeping existing QRL service modules
  - Exchange 1L with 5R; 1R with 5L (for compatibility of lines in the jumpers)
  - Rotate jumpers in the Q4, which implies a new pipe routing and consequent rebuild of the existing Q4 service module
  - Connection to DSL: new pipe routing inside the cryostat service module

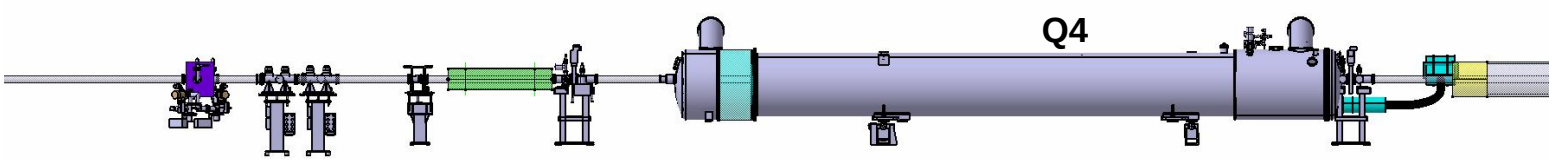
Courtesy D. Duarte

D2 – Q4 (LHC) vs Q4 (HL-LHC)

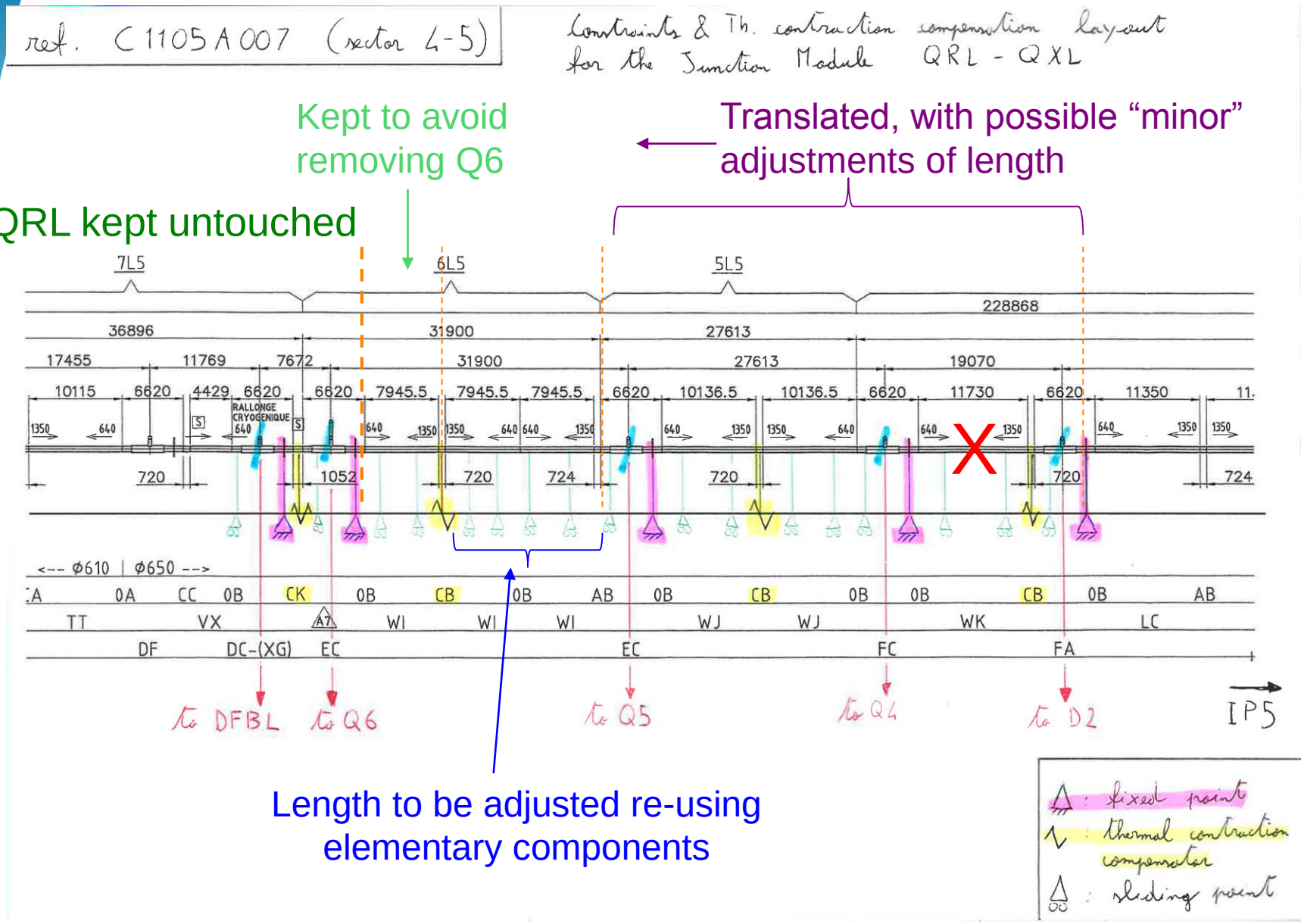
LHC



HL-LHC



Courtesy D. Duarte, M. Amparo



Courtesy S. Claudet, M. Sisti

Slight modification to proposed optics to maximize the re-use of the QRL elements

	LHC [m]	HL-LHC [m]	Diff [m]
Q4	169.553	179.600	10.047
Q5	196.490	207.490	11.00

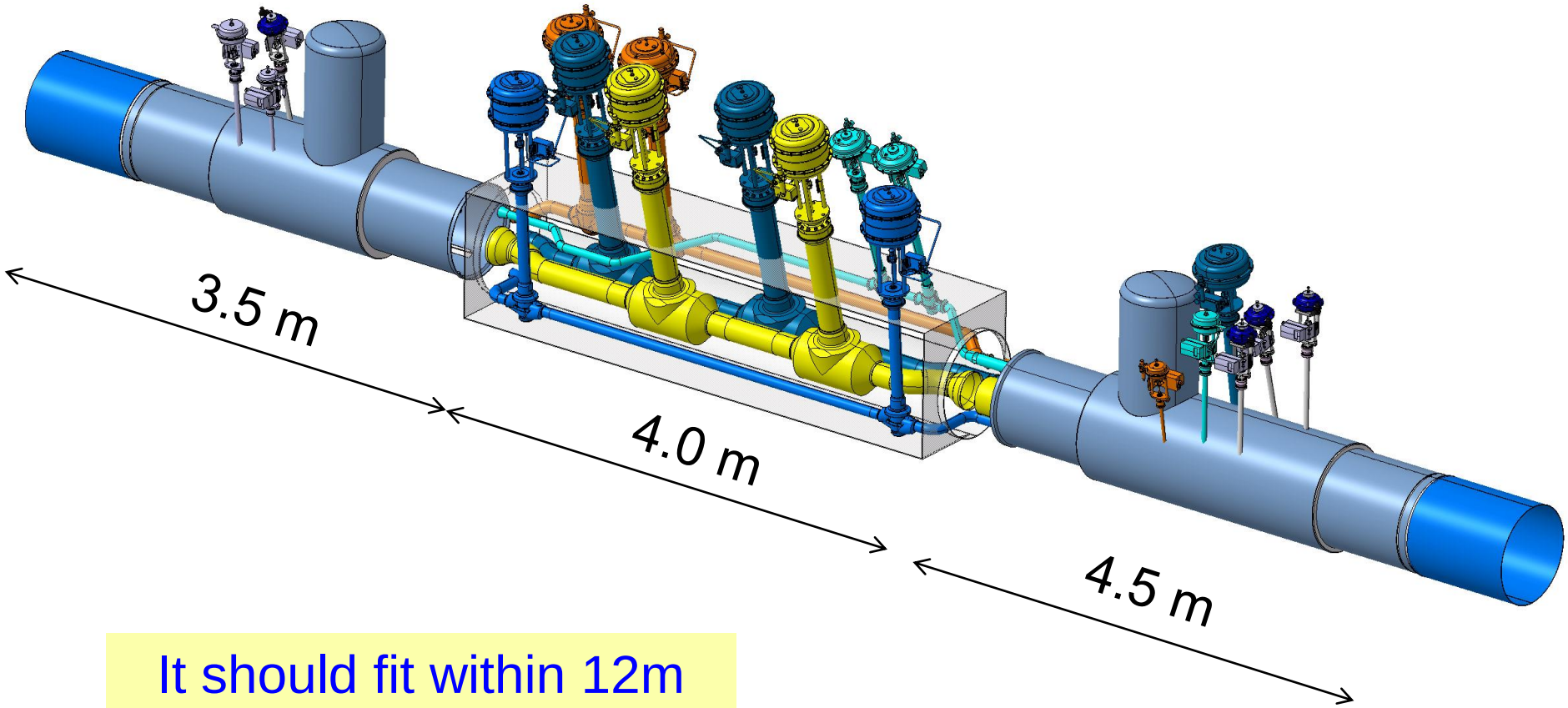
Both moved of 10.5 m !

Position changes in the 50 cm ranges are possible without further checks.
Larger changes might still be possible, but needs to be validated by recalculating the optics transition for β* from 50 cm to 30 m.

Courtesy R. De Maria

Junction module QRL-QXL

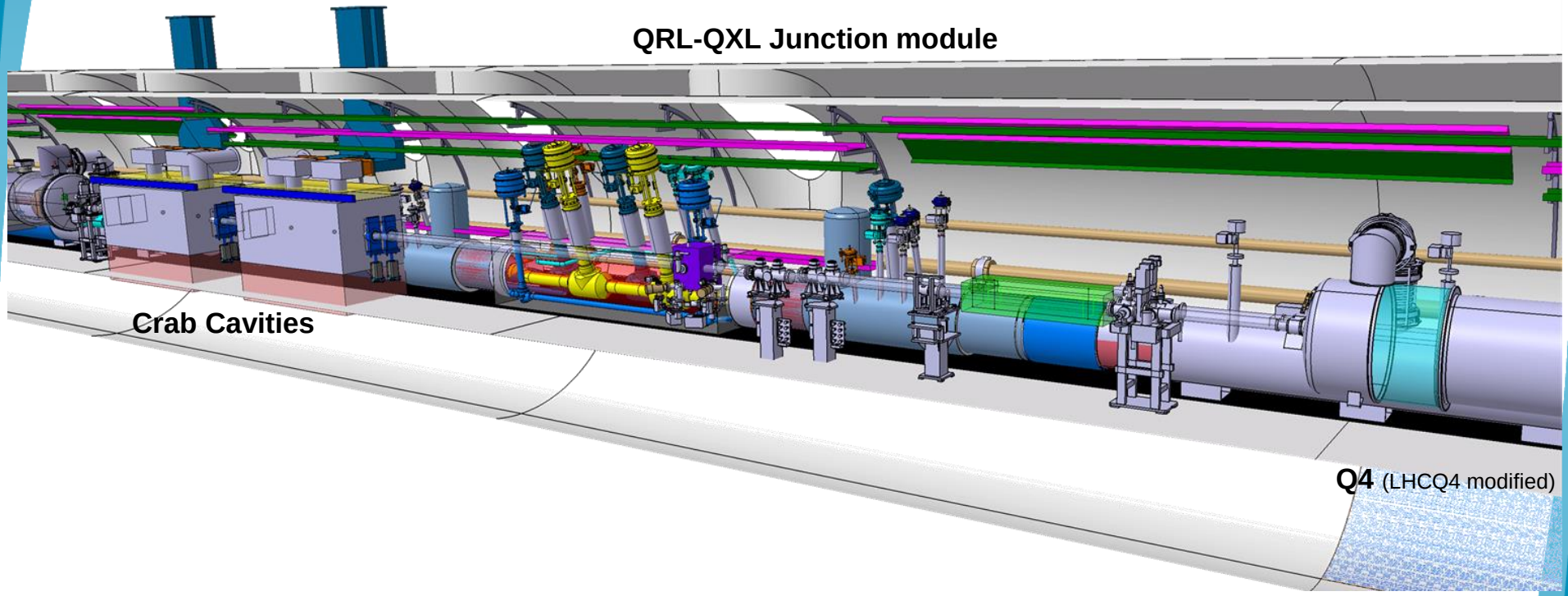
Work on-going



It should fit within 12m

Courtesy S. Claudet, M. Sisti

Crab Cavities – Q4 (HL-LHC)
QRL-QXL Junction module



Courtesy S. Claudet, M. Sisti, M. Amparo

Agreed listed of changes to be costed for the 31st of August I

WP	Changes and impact to be quantified in terms of costs

3	- Q6
	  o No de-interconnection no modifications
	- Re-use of LHC Q5 as HL-LHC Q5
	  o Possible change of the jumpers height (to be quoted as necessary)
	  o Change of the beam screen orientation
	- Re-use of LHC Q4 as HL-LHC Q4
	  o Swap of the Q4 between IPs and sides
	  o Rotation and modifications of jumpers
	  o Rotation beam screen
	  o Revision of cryostat and cryostat piping for conversion from semi-standalone to full standalone
	- Simplification and reduction spare policy and installation costs

6B	- Reduction of circuits because of reduction of the corrector and therefore reduction PC - Simplification and reduction spare policy and installation costs
7	- Reduction of circuits because of reduction of the correctors and therefore reduction protection system - Simplification and reduction spare policy and installation costs

Agreed listed of changes to be costed for the 31st of August II

9	- Reduction of the QXL extension - Adaptation of the QRL - Simplification and reduction spare policy and installation costs
12	- **New vacuum lay-out with new remote alignment** - Q4 and Q5 beam screen coating in the magnet/new beam screen if not possible to rotate them recovering
CONS	- Repair of corrector MCBY in Q4 5L

Next Steps I
discussion with WP6A to agree a DSL modification strategy

- Next steps meeting on the 29th to discuss technical options basic idea:
  - DSL partial re-use
  - Till Q6 connection no modification
  - From Q6 till Q4 possible re-use of pipe elements and cable strategy to be defined
- Suppression of procurement of leads for the new Q4 and for the modification of the Q5 for the correctors powering

Conclusions

- Remote alignment
  - In the next weeks we will focus on
    - Defining the new collimator alignment baseline
    - Trying to see how much we can couple elements together
    - Revising, checking, optimizing the vacuum lay-out
    - Complete the checks in the experimental areas
- Matching sections
  - Major stakeholders have the technical solution clarified and will provide costing for the 31/08
  - The definition of the technical solution for the WP6A is the next key step
  - For WP9 the definition of the degraded operation modes it is important to complete the QRL modification study (see next presentation)

Spare slides

no changes to the baseline

Monitoring and alignment of

- Q1, Q2a, Q2b, Q3, CP and D1
- TAXN
- D2
- Crab Cavities

with motorised jacks and monitoring sensors

minor changes to the baseline

A Full Remote Alignment would allow to reuse the LHC Q4 and Q5.

- No change in the concept of alignment with jacks.
- Modification on the magnets reference points in order to host the new sensors at their new positions

TAXS to Q1

TAXS alignment

Manual alignment option chosen as less than 10 µSv/h after 8 weeks of cooling time in LS5.

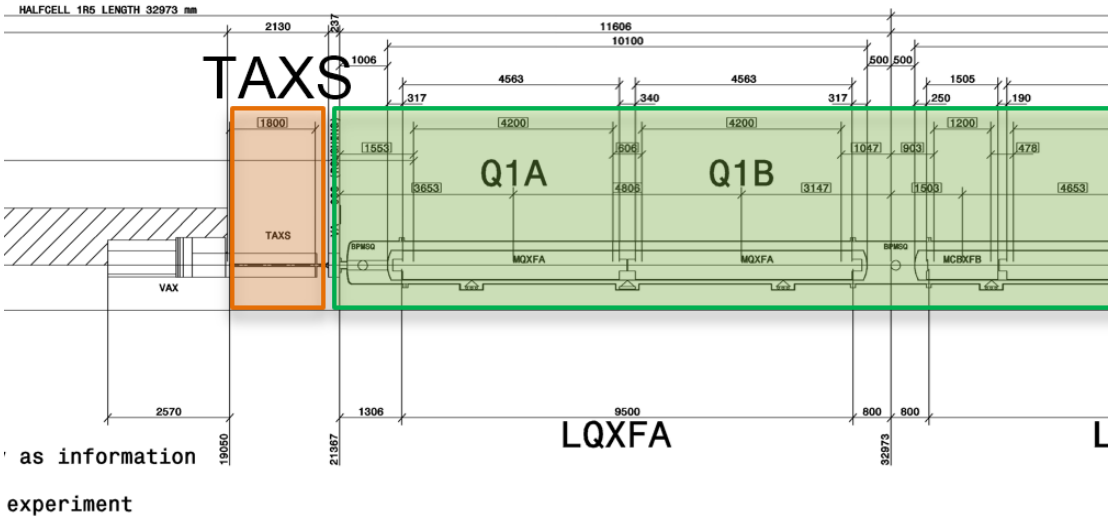
+

No maintenance of motors in highly radioactive area as TAXS is covered in shielding blocks.

Adjacent valve on VAX has enough aperture to stay fix; connection to Q1 will follow alignment of TAXS.

-

TAXS alignment takes approximately one week in case it has to be done during run considering equipment preparation, measurements and alignment.



Next steps

Identify what would be the impact of a TAXS misalignment of 2 mm from a radiation point of view. (see with RP)

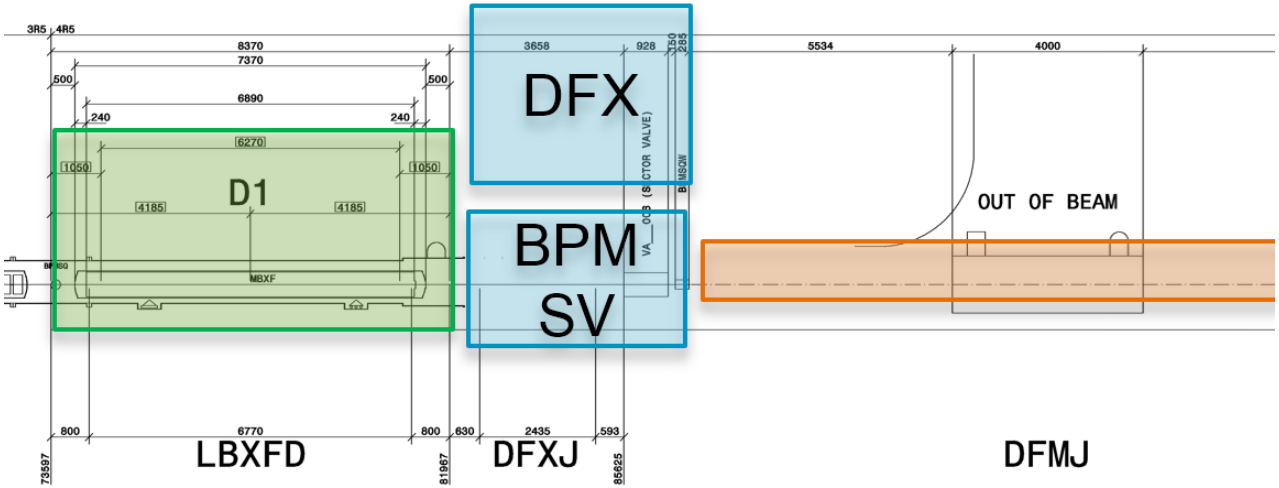
Is TAXS aperture sufficient in the case of a LSS displacement of 2.5 mm? (see with WP)

Get information if a stop of 1 week for TAXS alignment during first run would be acceptable (case: IP shift) or if realignment needed.

Confirm that otherwise an alignment of TAXS is only foreseen during YETS / LS.

Meeting with WP planned beginning of July

D1 – beam line - DFX



Concept

Motorised D1 will have two independent components connection to it.

Relative movement tolerances of D1 with respect to DFX have not been investigated.

BPM and sector valve on plug-in survey platform (reason see collimators).

Proposal

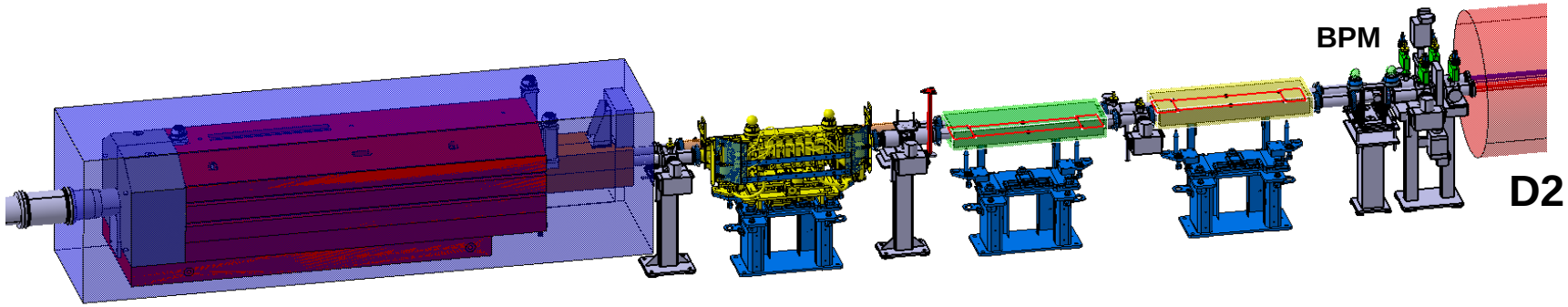
Identify with WP if DFX has to be aligned in case LSS is moved by 2 mm.

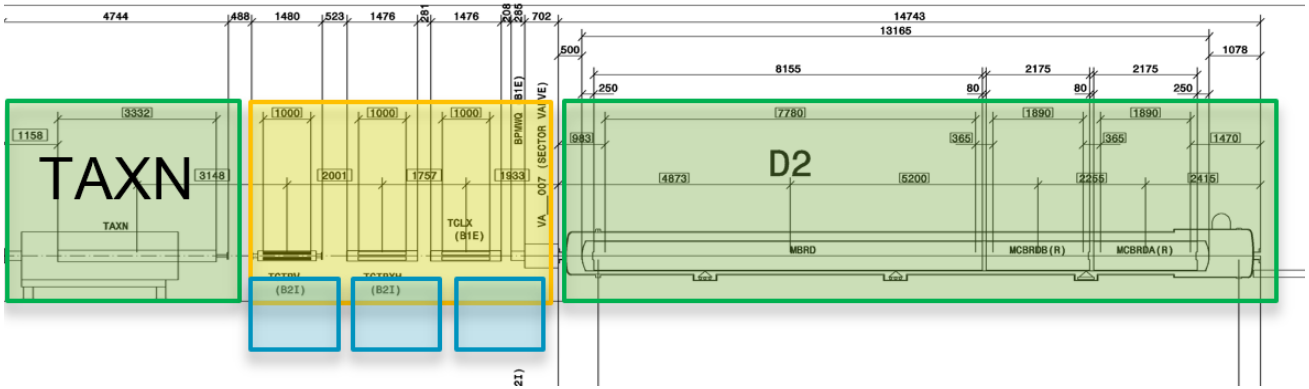
DFX support shall have survey platform interface in case the weight does not exceed approx. 2 tons.

Otherwise an alignment support shall be integrated that allows alignment from the corridor side.

BPM and sector valve on a plug-in survey platform. To be confirmed by BE-BI and TE-VSC.

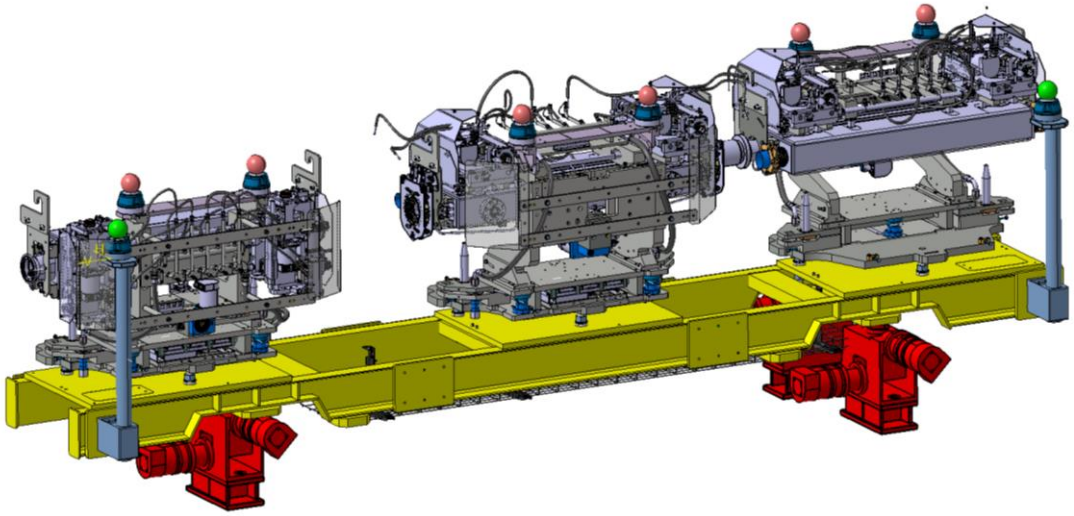
Collimators between TAXN and D2





Full Remote Alignment will allow to reduce the beam pipe diameter in the collimators and thus allow the design to build them.

Collimators between TAXN and D2

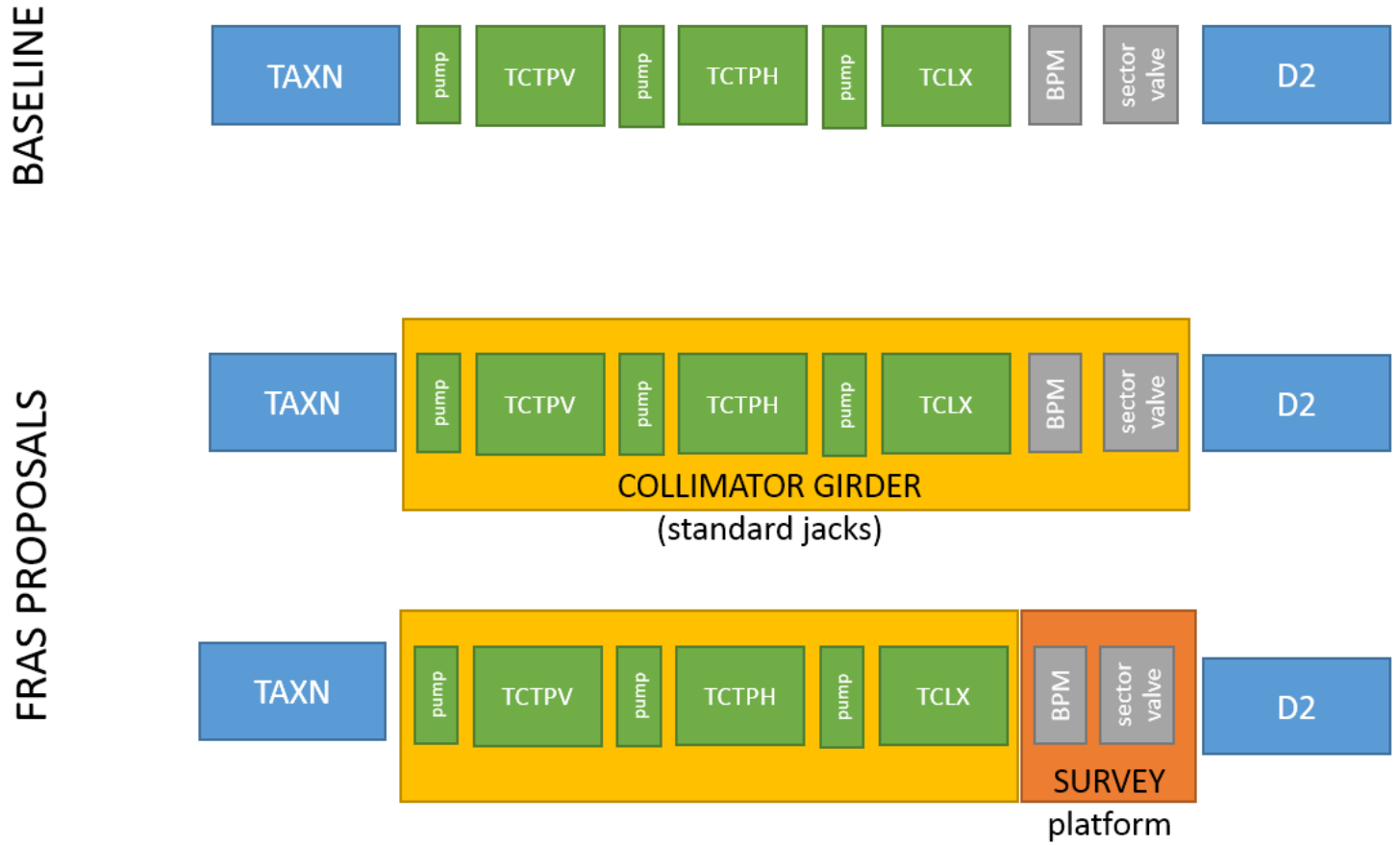


with the input from the collimators design team

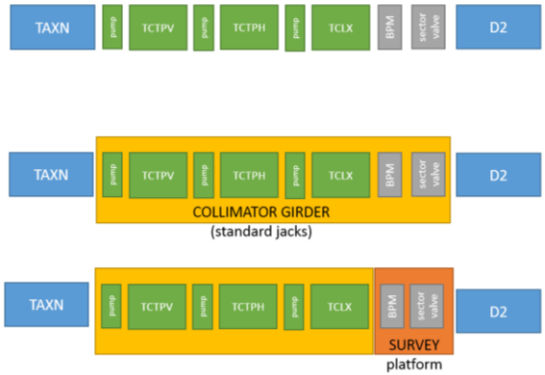
- Collimators can move together on a common girder
- Differences in fiducialisations in case of exchange will be compensated for with survey platform (plug-in) under each collimator
- Due to girder design the intermediate valves can be fixed on the girder without any active alignment platform

FRAS proposes to combine equipment on girder.

Collimators, BPM & sector valve



Collimators, BPM & sector valve



\+

Reduce number of permanent alignment sensors and motors as only girder is permanently equipped

Design possible also in case of “stand alone” collimators in case each collimator is equipped with sensors and motors. Intermediate components to be attached or also motorised.

\-

Combined equipment on girders needs agreement who is the equipment owner (responsibilities).

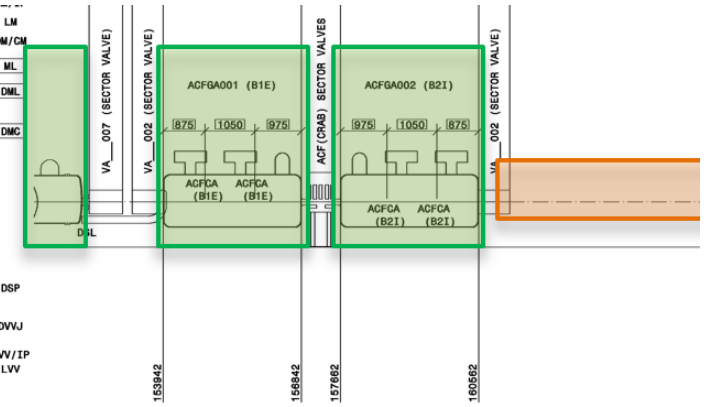
In case of stand alone components, the alignment concept and steps have to be studied very carefully as at the moment the 2nd beam pipe has a clearance of 2 mm: No big movements are possible!

Next steps

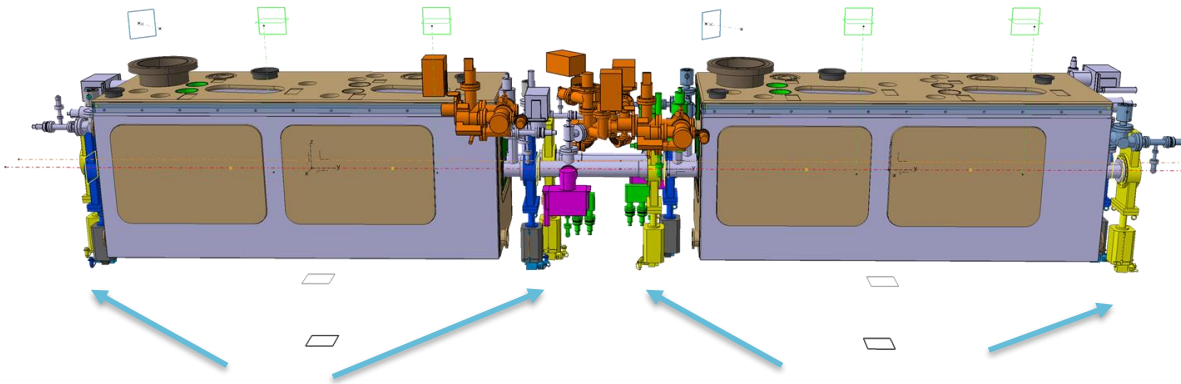
Get approval from WP for girder solution or technical reasons why a stand alone option would be preferable.

According to decision establish the layout, the according vacuum and alignment components and describe the alignment restrictions.

Crab Cavities



Teddy Capelli



attach to Crab Cavity 1

attach to Crab Cavity 2

Status

EN/MME proposed to support vacuum equipment and connection modules between the two Crab Cavities.

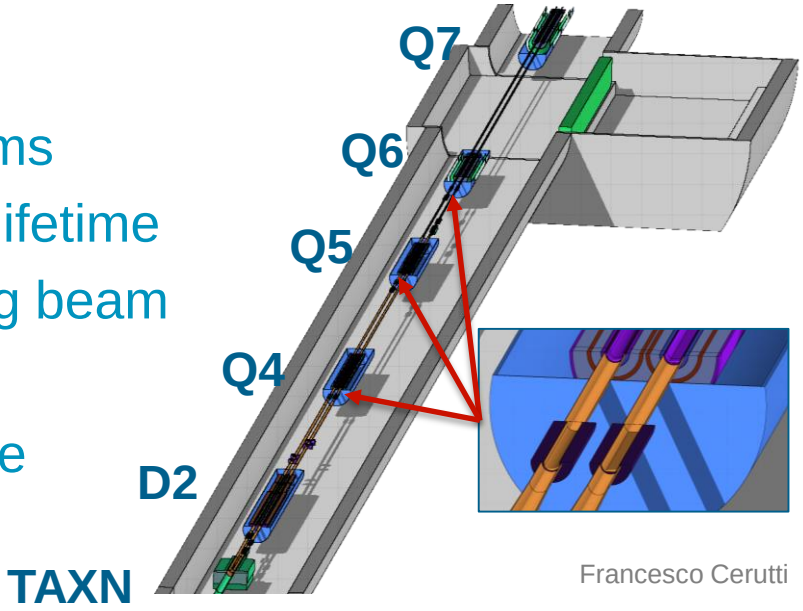
Proposal

- get formal approval from WP to make supported vacuum equipment as design baseline.

masks Q4 and Q5 (+Q6)

- masks will be installed on both beams
- equipment is designed for HL-LHC lifetime
- driving mask is the mask of outgoing beam

- no design of the equipment available

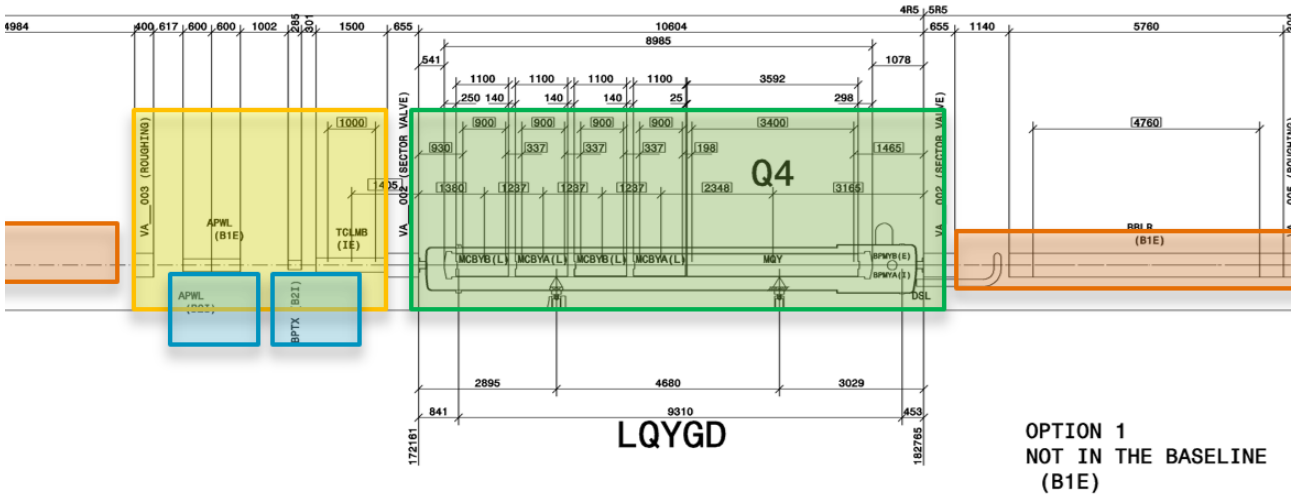


Francesco Cerutti

Proposal

- heavy duty survey platforms proposed
- platforms must be motorised to follow Q4/Q5
- alignment sensors installed
- to see if combined with other equipment in zone (see next slides)

mask Q4 and adjacent components



Option A

- Mask Q4 independently on heavy duty survey platform with permanent motors
- APWL equipment also on survey platform

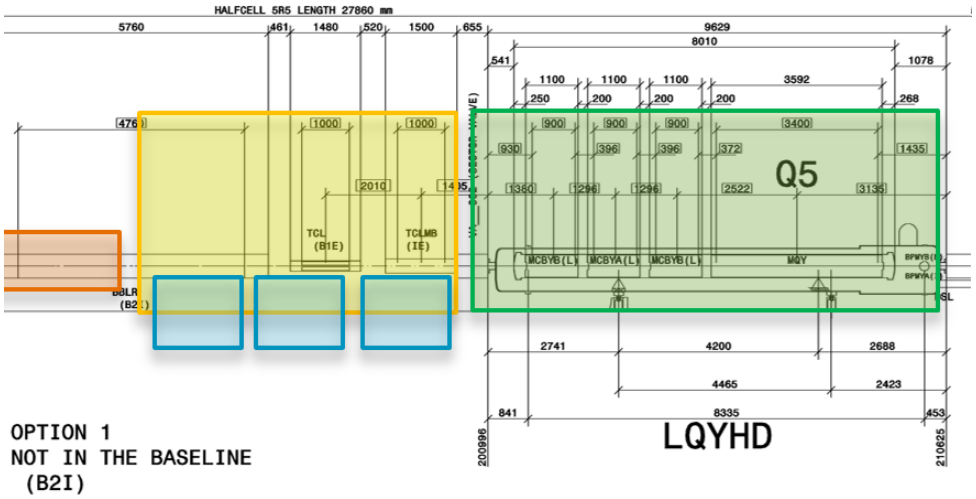
Option B

- APWL can be moved close to mask Q4
- Common girder for both components and plug-in platforms for each component
- Sector valve between mask and Q4 passive on girder

Next steps

- Identify responsible for APWL and discuss solution which option would be preferred.
- Get confirmation from masks responsible for alignment proposal and assumptions taken.

mask Q5 and adjacent components



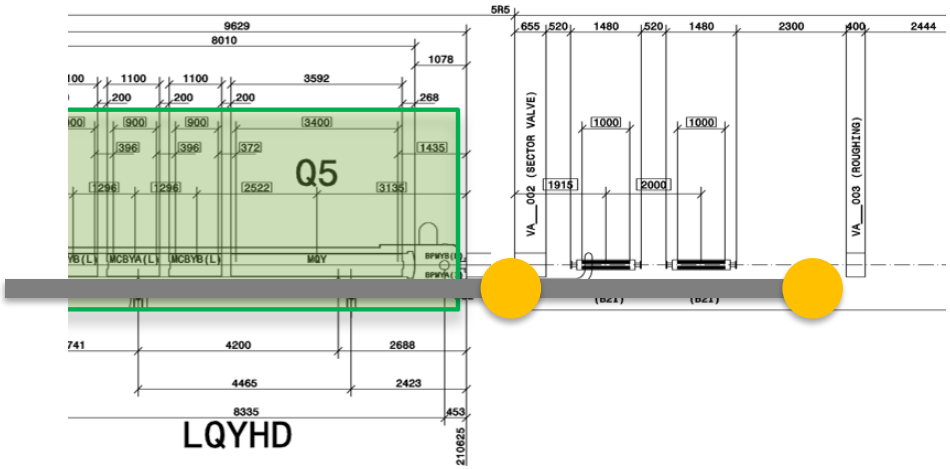
Option A

- Mask Q5 and TCL collimator independently on heavy duty survey platform with permanent motors

Option B

- Common girder for both components and plug-in platforms for each component
- Sector valve between mask and Q5 passive on girder

collimators between Q5 and Q6



Status

WP15.4 has to integrate the end of the alignment system after Q5.

The estimated radiation dose of the collimators was expected to be low – check with RP if affirmation changed.

Proposal

Get confirmation of initial estimation by RP.

Use heavy duty survey platform in any case for the collimators.

Identify if there is an added value for OP or collimator team to monitor them permanently.

Next steps

- WP15 discusses on a formal basis with other WP for confirmation of proposed solutions or technical suggestions from WPs.
- Definition of final assembly and alignment tolerances for LSS equipment by Working Group on Alignment.
- Definition of final beam size at DCUMs in LSS by BE-ABP.

Mandatory for design of Full Remote Alignment

Basis for component and cost estimation.