# Status of automatic measurements

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

# Outline

- Context
- Solution proposed
- Next steps

# Context

- ✓ High radiation level → limited intervention time to perform the measurements
- ✓ From the FRAS functional specification:
  - All relative misalignments between adjacent components will be recorded in order to monitor the impact on the vacuum bellows.
  - The position of the corresponding vacuum bellows will be deduced from the position of the adjacent components on which they are attached
  - The position of all other bellows, pipes and RF waveguides will be controlled w.r.t. the tunnel main components during LSs.
- ✓ Just the control of position, no adjustment foreseen
- ✓ Use of permanent targets

# Context

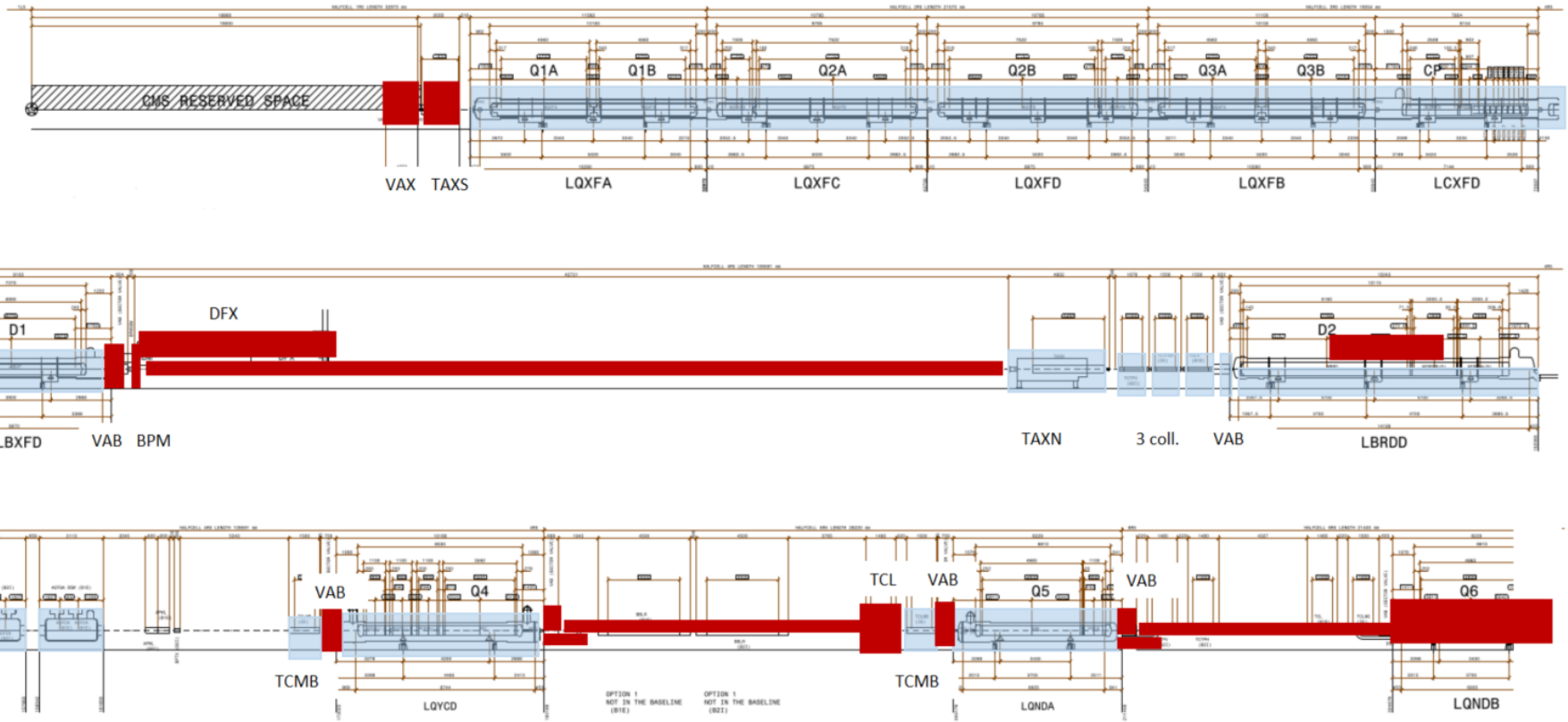
List of the intermediary components:

- BPM after D1
- DFX, DFM
- Cryolink
- APWL, BPTX
- TCL

+ QXL jumper flanges

+ Crab cavities RF waveguides

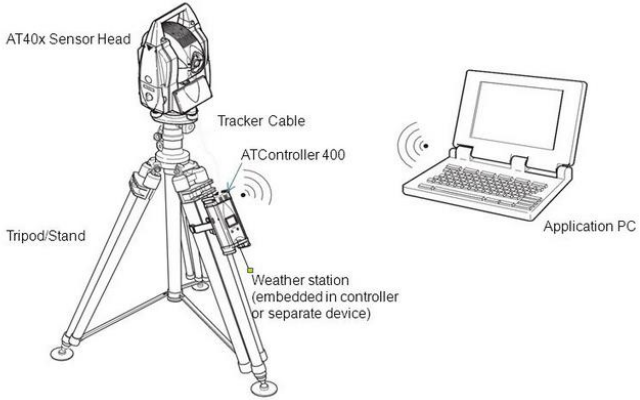
+ VSC components (transition chambers, drift vacuum chambers, vacuum modules)


CMS RESERVED SPACE
Q1A
Q1B
Q2A
Q2B
Q3A
Q3B
CP
VAX
TAXS
LQXFA
LQXFC
LQXFD
LQXFB
LCXFD
D1
DFX
D2
LBXFD
VAB
BPM
TAXN
3 coll.
VAB
LBRDD
VAB
VAB
Q4
TCMB
LQYCD
TCL
VAB
Q5
VAB
Q6
TCMB
LQNDA
LQNDB
To be measured during YETS and LS
Remote alignment

# Context: strategy of alignment

- Fiducialisation on surface: installation of 0.5” or 1.5” standard fiducials + permanent targets
- Initial alignment w.r.t. tunnel underground geodetic network
- “Smoothing” w.r.t. adjacent components → Determination of the position at t0.
- Follow-up of the position, every YETS or LS
- Determination of the delta and storage in a database.

# Solution proposed



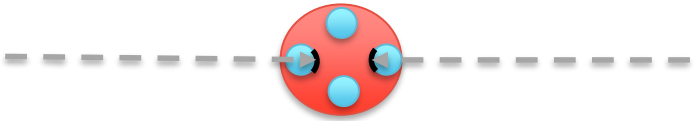

- Development of a semi-automatic method of measurement using laser tracker, knowing that one in place, these instruments can be piloted remotely.
- This implies:
  - The booking of lines of sight in the 3D models, from “repeatable” and known station location,
  - The installation of permanent fiducials during the fiducialisation (or installation process).

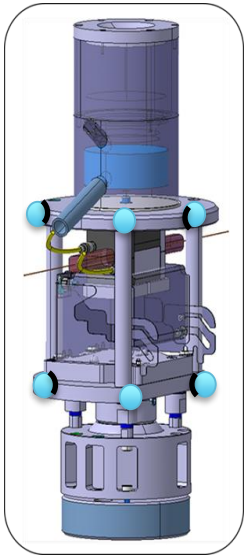
# Solution proposed

- Install the laser tracker at the same location and height on the tunnel floor, to keep the same lines of sight towards the targets of the components (save time of installation, be sure that there will not be any obstacles along the lines of sight).
  - Integration of the lines of sights in the 3D models
  - Marking of the laser tracker station on the tunnel floor
  - Use of a plug-in version (SPS example)
  - A robot station could be put in place as well in very radioactive areas.

# Solution proposed: permanent targets

- Target = glass sphere with coating.
- One drawback: the orientation of the target towards the measurement instrument
  - Use of a specific target (with 3 glued target)
  - Configuration of spheres according to the lines of sight

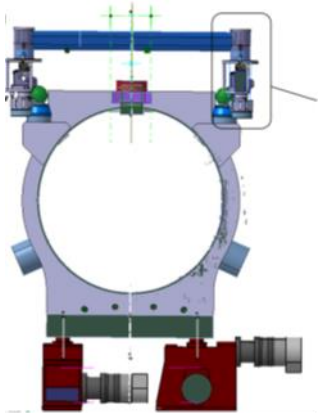


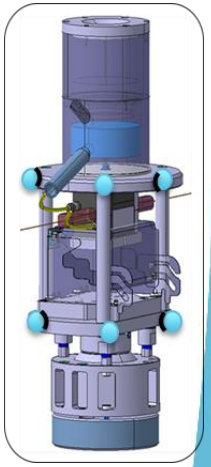


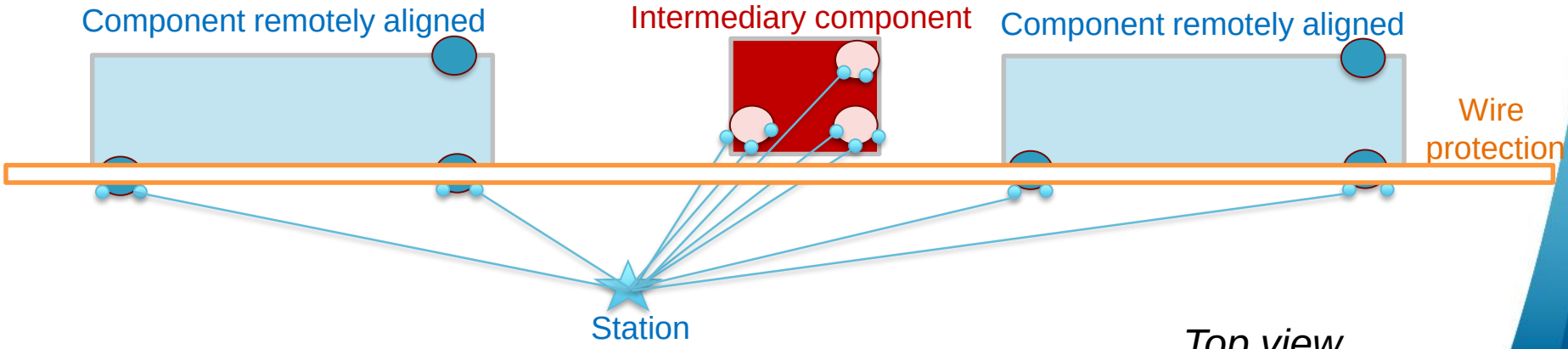
# Solution proposed: concept

How to perform the measurements w.r.t. the main components?

- Use the targets of the permanent sensors supports: their position is known (within a 10 µm accuracy) in the referential frame of the support.
- The position of the stretched wire is known (within a 5 µm accuracy in the referential frame of the WPS).
- Micrometric repeatability to install the WPS on its support



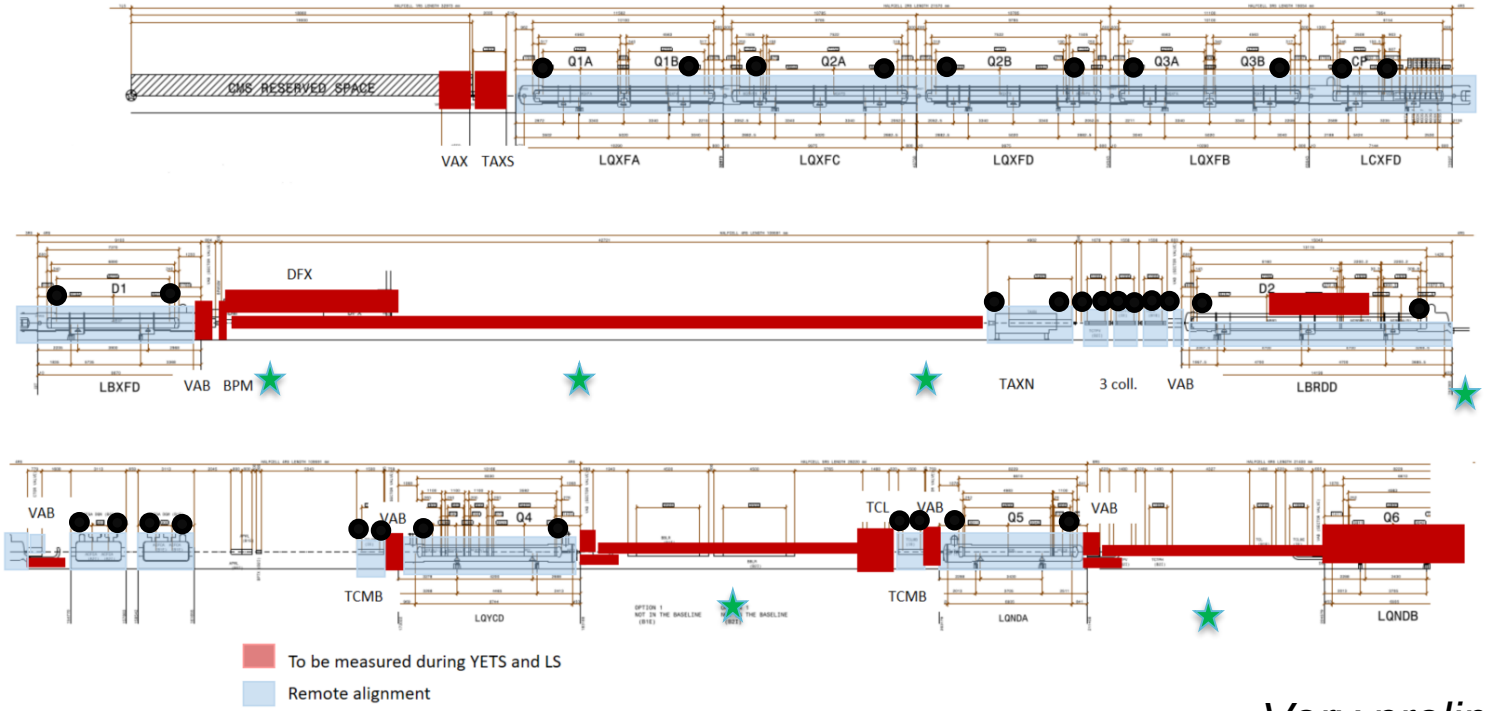





*Top view*

# Solution proposed: configuration

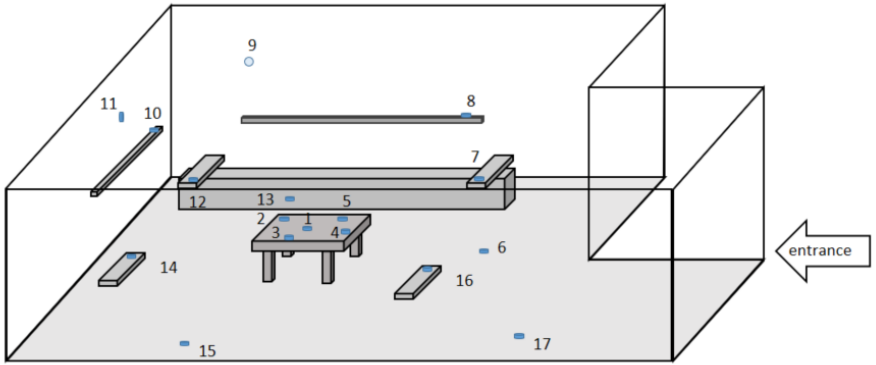
- How to perform the measurements w.r.t. the main components?




*Very preliminary*

# Solution proposed: first results

- All visible points measured with regular 0.5’’ CCR using precise mode (2 circles, 5 seconds each)
- All visible points measured with 0.5’’ glass ball with coating using precise mode
- Additional measurements (another station / one circle measurements / max distance)
- Data comparison



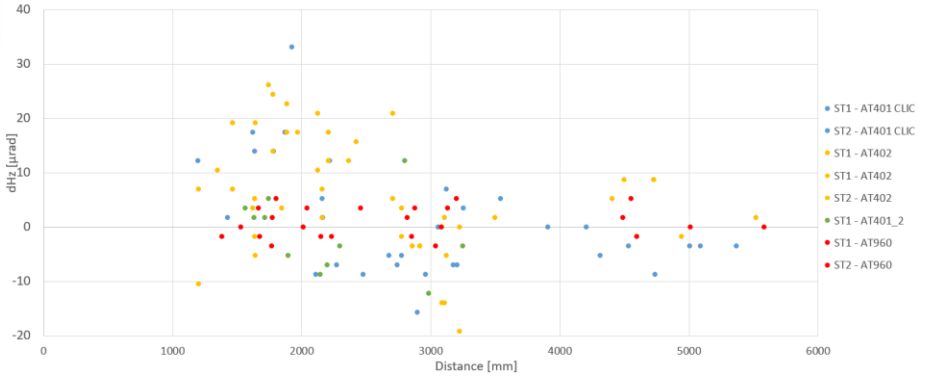

Series of measurements in SU geodetic base using:

- AT401 (CLIC)
- AT402 SN392506 (ASG)
- AT401 390769 (ASG)
- AT960 (ASG)

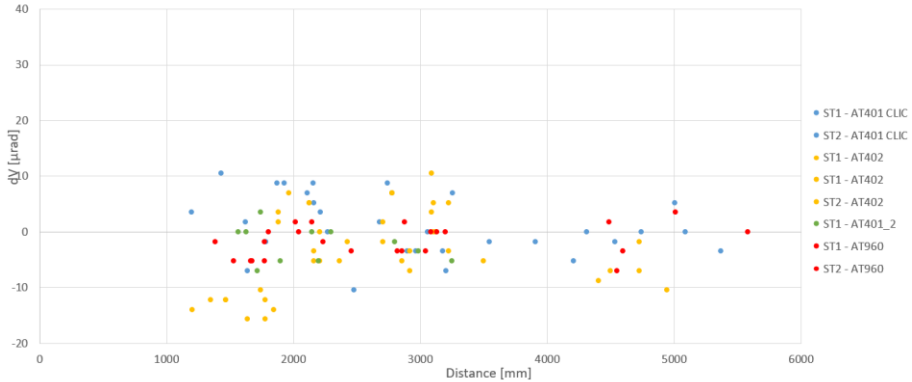
From A. Zemanek (June 2018)

# Solution proposed: first results

Horizontal angle:



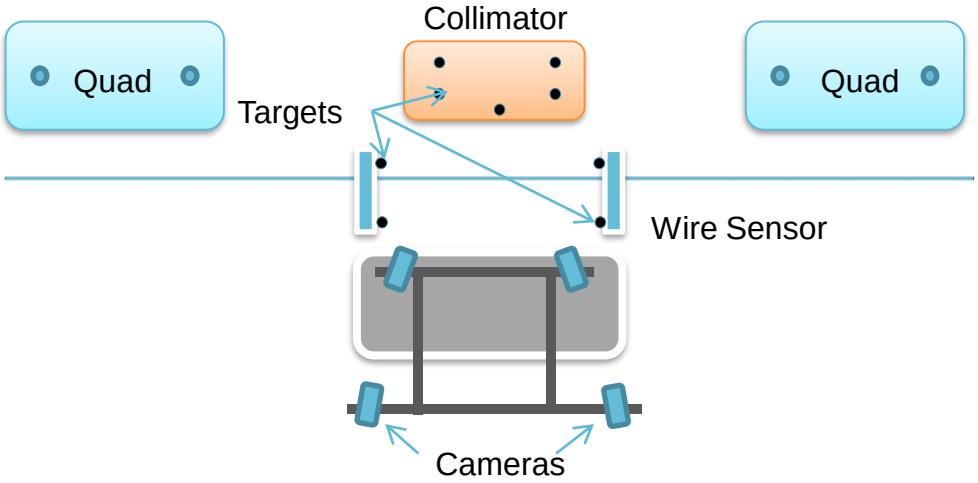

Vertical angle:

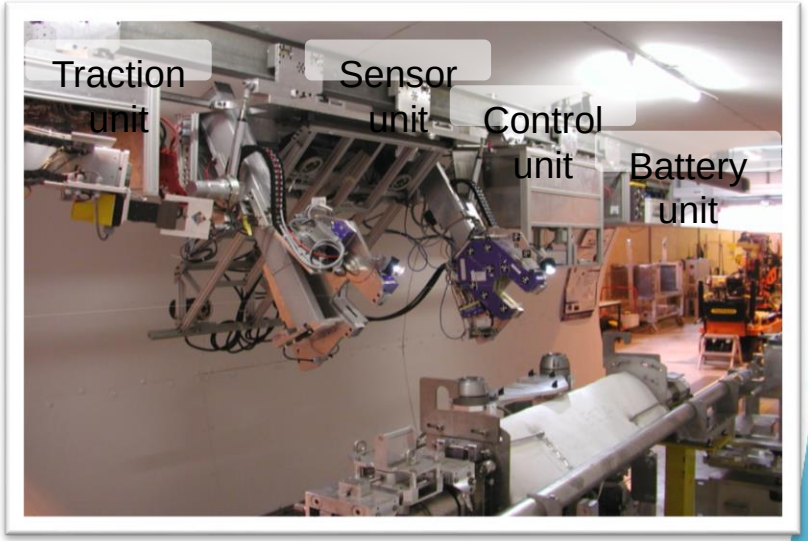


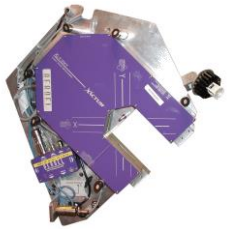

- Measurements performed with the CCR are considered as the reference.
- AT960 gave the best results
- AT401_2 didn't measure above 3.6 m

From A. Zemanek (June 2018)

# Another solution



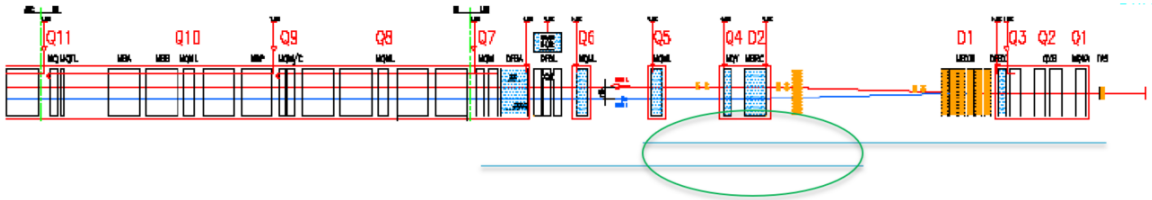



Determination of the wire by photogrammetry

# Another solution

## Link to the HL-LHC




- This second version could be used
  - For the collimator survey of course
  - for the link between the permanent stretched wire and standard offset wire

D.Missiaen, Revue interne pour les activités de survey HL-LHC,17 juin 2019, CERN

Two drawbacks:

- A temporary wire has to be installed during them measurements between D1 and Q6
- The stretched wire can not be protected from air currents as it has to be visible for the photogrammetric measurements

# Next steps

- Perform simulations according to the configuration we will have in the tunnel to chose the best position for the measurement stations
- Book the position of the stations and lines of sights in the 3D models
- Propose “plug-in” pillars
- Launch a deeper study on the measurements carried on coated glass sphere
- Validate the concept of measurements on a test setup (the string test would be a very good place)
- Study the possibility to use a robot to install the Atxxx at the correct position.

- No resources are currently available for such a study.


***Thank you very much***