MDI alignment plans

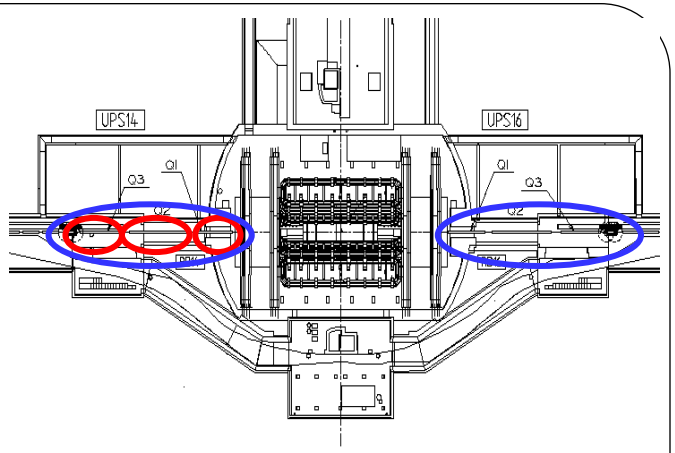
IWLC2010 International Workshop on Linear Colliders 2010

H. MAINAUD DURAND,
on behalf of the CLIC active pre-alignment team

SUMMARY

- ✓ Introduction
  - Case of the LHC low beta quadrupoles
  - Case of CLIC main linac
- ✓ Alignment requirements in MDI area
- ✓ Solutions proposed for CDR and plans for TDR

Introduction : case of the LHC



The alignment functions

F0 – Fiducialisation

➔ *better than 0.1 mm r.m.s, but in the tunnel ~ 0.2 to 0.3 mm*

F1 – The alignment of one inner triplet w.r.t to the main elements of the corresponding arc and LSS

➔ *smoothing: ± 0.1 mm r.m.s. in radial and vertical*

F2 – The alignment of the experiment w.r.t. "machine geometry"

➔ *uncertainty of position of any fiducial mark in the cavern reference network w.r.t the « machine geometry » is expected to range from 0 .5 to 1.2 mm r.m.s.*

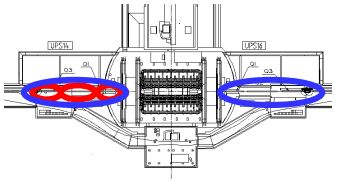
F3 – The alignment of one triplet w.r.t. the other inner triplet (left/right side)

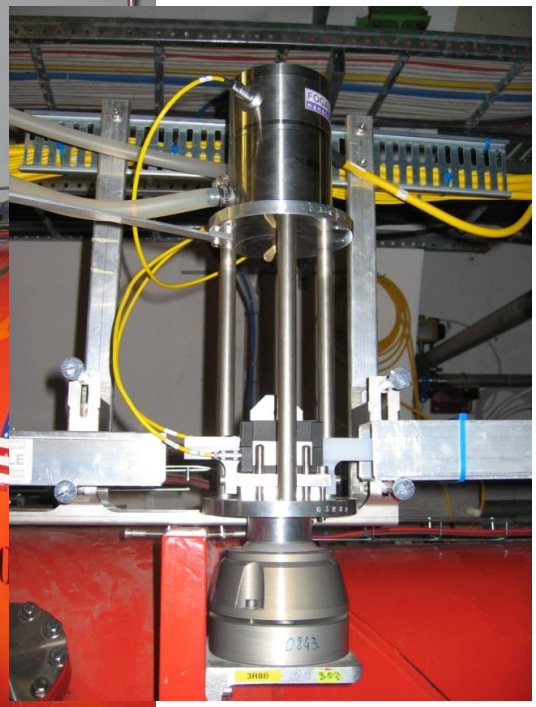
➔ *positioning: ± 0.1 mm r.m.s. in radial and vertical*

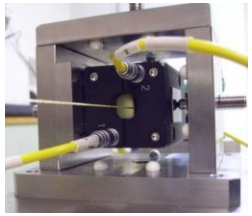
F4 – The alignment of the quadrupoles w.r.t each other

➔ *monitoring of the stability within a few microns*

Introduction : case of the LHC

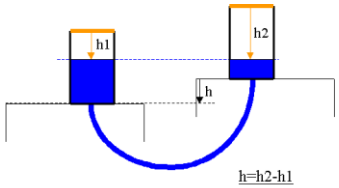




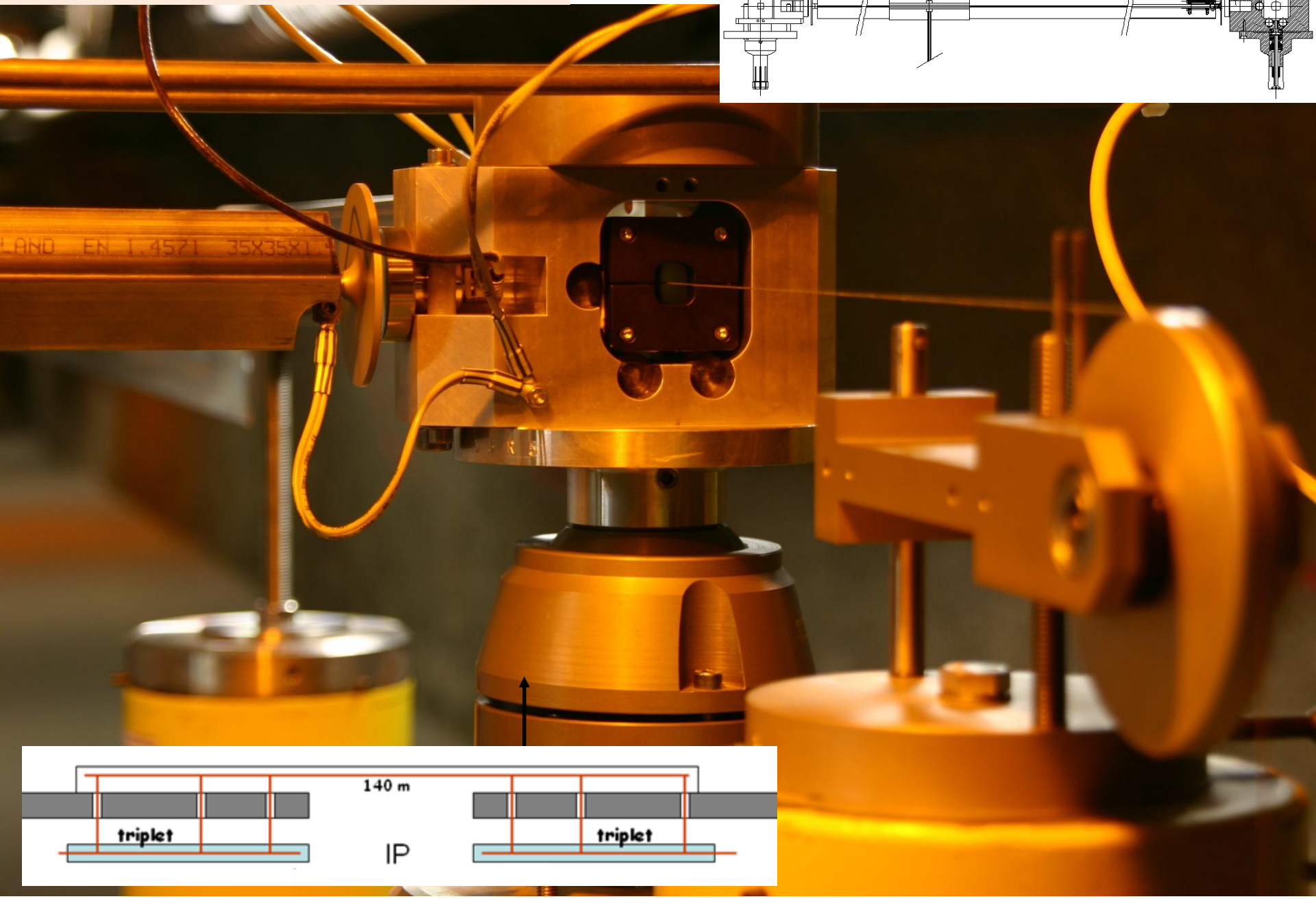


2 types of alignment systems:

- Wire Positioning System WPS (reference of alignment : wire; sensors measuring the vertical and transverse offset w.r.t the wire (sub micrometric resolution)
- Hydrostatic Levelling System HLS (reference of alignment is a water surface; sensors measuring the vertical distance w.r.t the reference)

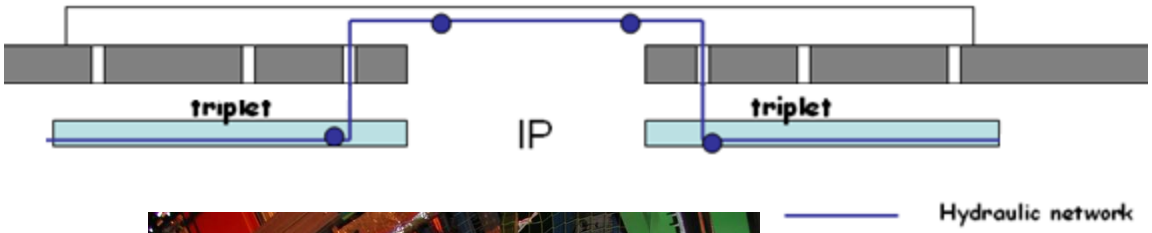


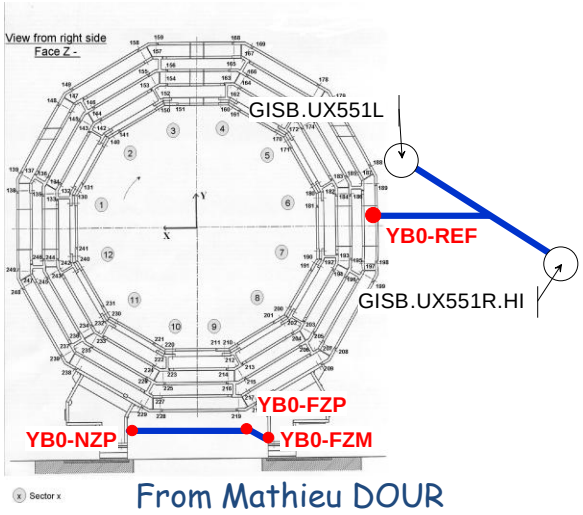
Radial link between left and right side



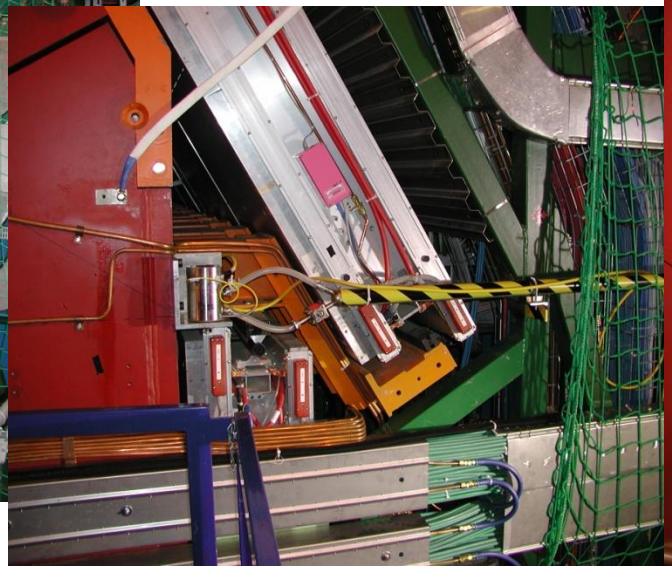
Introduction : case of the LHC

Vertical link between left and right side





From Mathieu DOUR



Introduction : case of CLIC main linac

Mechanical pre-alignment

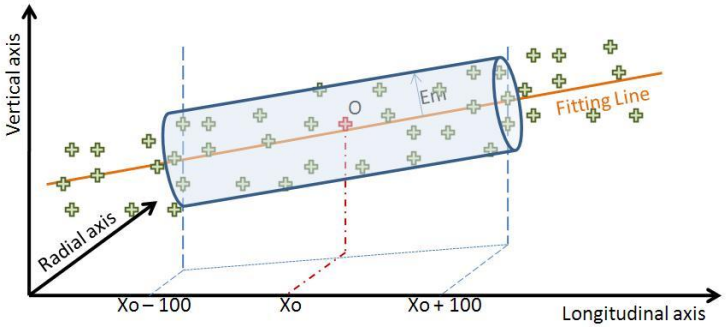
Within +/- 0.1 mm (1σ)

Active pre-alignment

Within ± 14 μm (1σ)

Beam based alignment

Beam based feedbacks



After computation, for a sliding window of 200 m, the standard deviations of the transverse position of the zero of each component w.r.t. the straight fitting line must be inferior to 14 μm

Active pre-alignment = Determination of the position of the components in a general coordinate system thanks to alignment systems

+

Re-adjustment thanks to actuators

General strategy: determination of the position of the components

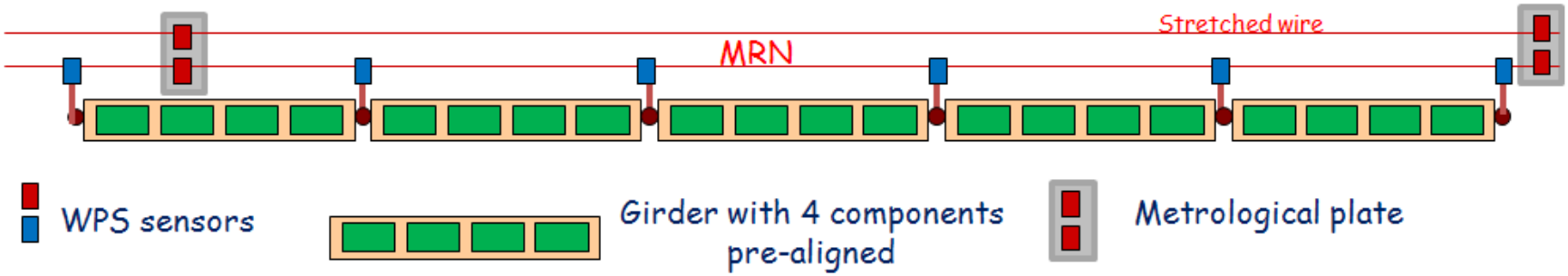
(See presentation of this morning)

Geodetic Reference Network (GRN)

Metrologic Reference Network (MRN)

Support Pre-alignment Network (SPN)

Alignment and fiducialisation of each component on the supports (AFC)



For CDR:

- ✓ reference for MRN and SPN networks: stretched wires,
- ✓ sensors coupled to each support to be pre-aligned: WPS sensors
- ✓ vertical sag of stretched wire modelled using HLS system coupled with WPS

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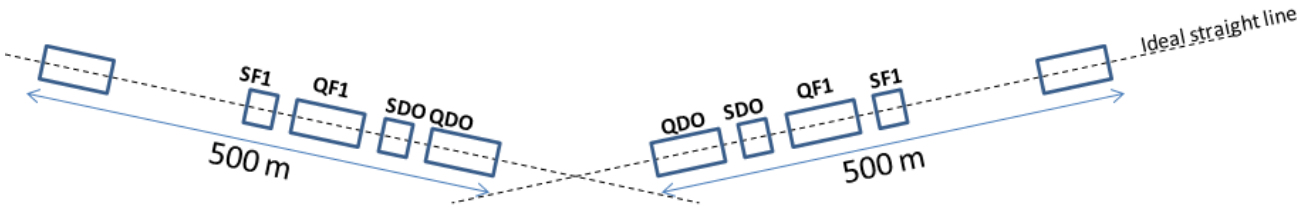
Requirements for MDI area



Determination of the position of QD0 w.r.t other components of the BDS (last 500 meters)

- ✓ Position of the zero of QD0 w.r.t ideal straight line of the last 500 meters of BDS: ± 10 µm rms (including fiducialisation)
- ✓ Same requirement for all the components of BDS
- ✓ Longitudinal relative position between QD0 and QF1: ± 20 µm rms

Left w.r.t right side of BDS

- ✓ Monitoring of the position of left QD0 / right QDO within ± 5 µm rms
- ✓ Determination of left BDS reference line w.r.t right BDS reference line : within ± 0.1 mm rms
- ✓ Monitoring of left BDS reference line w.r.t right BDS reference line : within a few microns

Requirements for MDI area

Detector w.r.t BDS geometry

- ✓ Same requirements as LHC (to be confirmed)

Adjustment

- ✓ Sub-micrometric resolution of displacement along 6 DOF
- ✓ Compatible with sub-nanometric requirements of stabilization
- ✓ Large range: ± 5 mm at least (to cover offsets in the re-installation of QD0)

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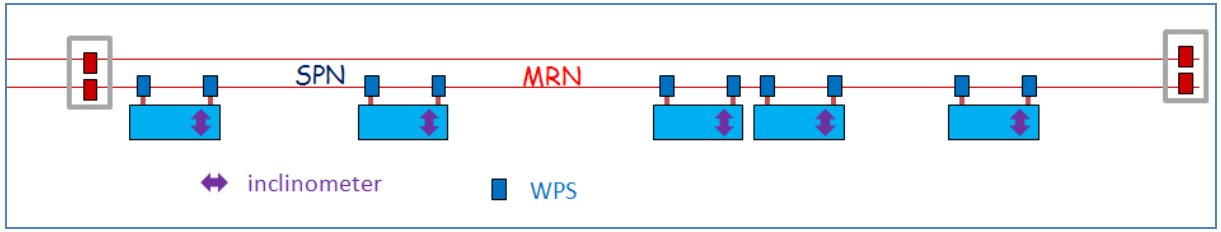
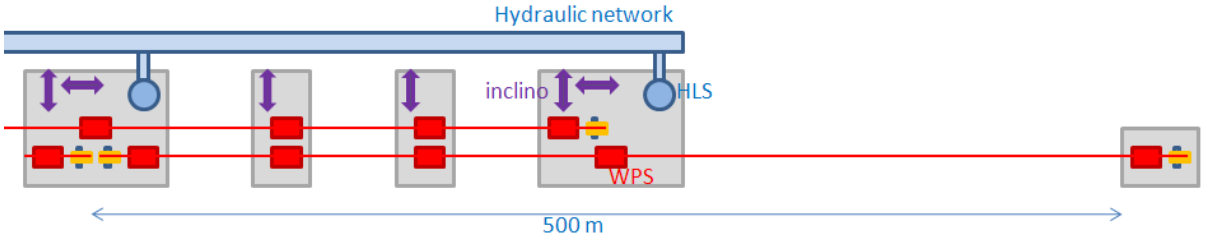
Solutions for MDI area

Determination of the position of QD0 w.r.t other components of the BDS (500 last meters)

- ✓ Fiducialisation of the mechanical zero of QD0 measured on a CMM machine with an uncertainty of measurement below 1µm.
- ✓ Same solution of alignment, using stretched wire and WPS sensors, proposed in BDS



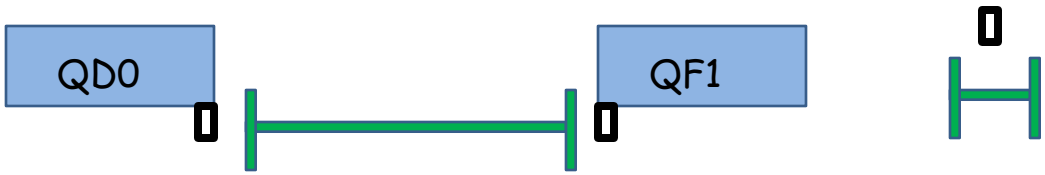
- ✓ Main difference concerns the MRN network (due to lack of space):
  - No overlapping of stretched wires in the last meters
  - No HLS system needed for the modeling of the sag at the extremity of the stretched wire, which will be extrapolated on the last meters.



Solutions for MDI area

Determination of the position of QD0 w.r.t other components of the BDS (500 last meters)

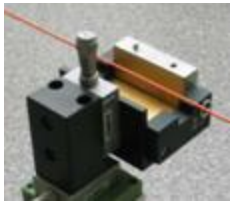
- ✓ Longitudinal monitoring of QD0 w.r.t QF1: capacitive sensors coupled to each component measuring w.r.t targets of a common carbon bar



Capacitive sensor

Carbon bar with targets on both extremities

- ✓ Development of special mechanics and sensors to displace the stretching device when QD0 is removed.
  - Development of « opened » WPS sensors



  - Fixed part of stretching device will have to be displaced remotely, radially (get out the WPS installed on QD0) and longitudinally (get out the support tube of QD0). Can not be removed as it gives an alignment reference for all the BDS components over the last 500m.

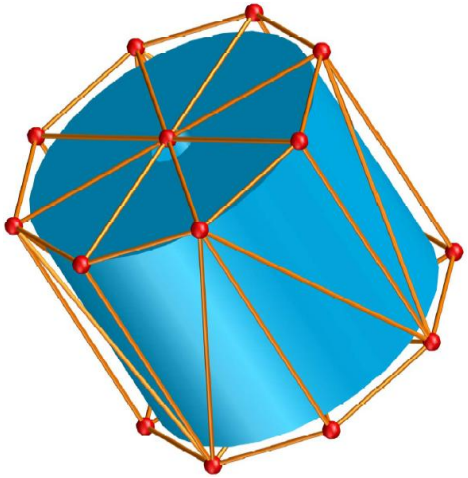
Next steps

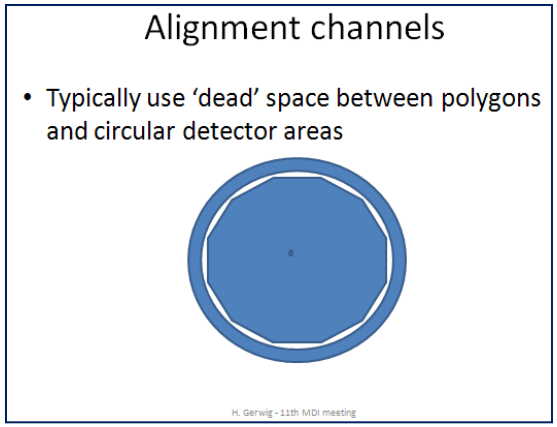
- Propose a design for these solutions and integrate them
- Validate propotypes on dedicated mock-ups

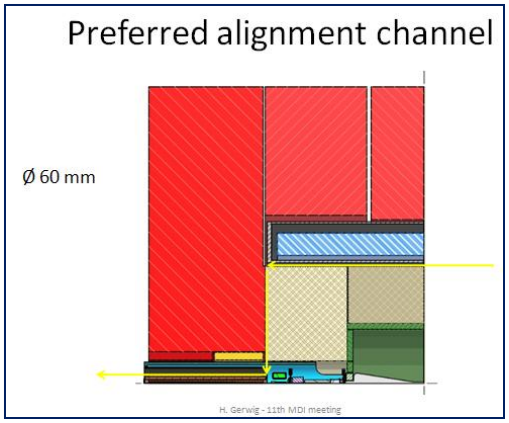
Solutions for MDI area

Left side w.r.t right side

- ✓ Monitoring of QD0:
  - Network of over-determined nodes linking each QD0
  - Each node consists of a combination of RASNIK systems performing measurements through the detector, using the dead space between polygons and circular detector areas
  - RASNIK systems calibrated with a sub-micron accuracy
  - This project is part of a collaboration with NIKHEF institute.







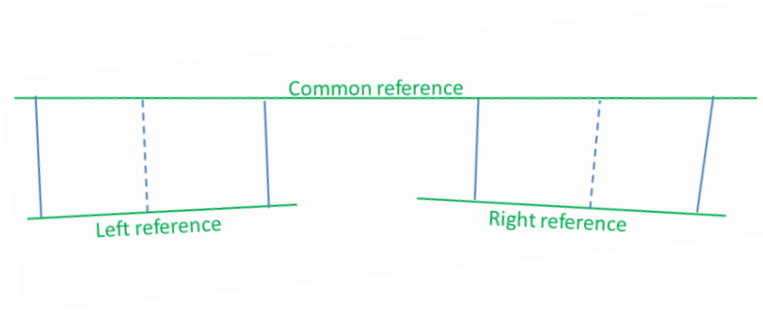
Next steps

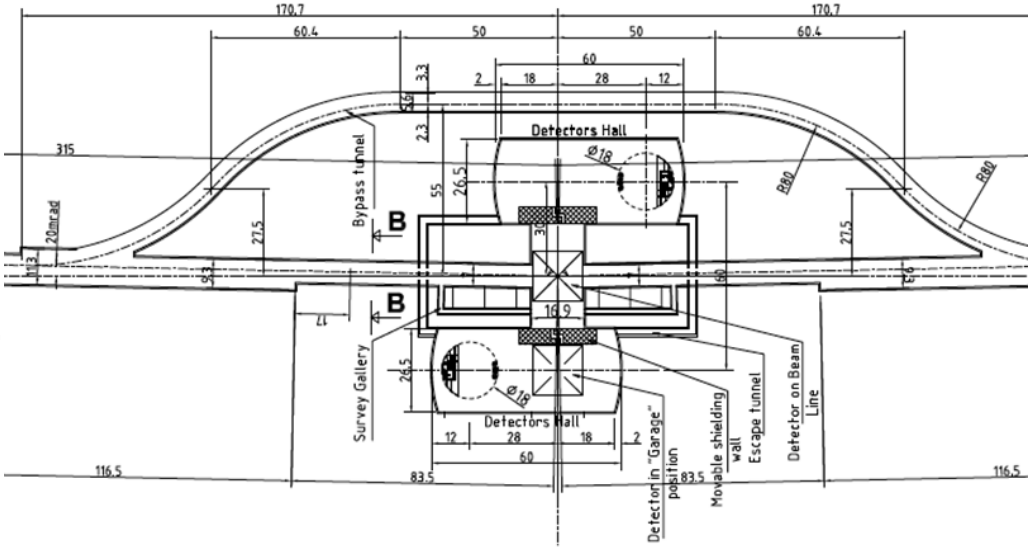
- Perform simulations of configurations
- Design and calibrate nodes of RASNIK
- Validate the solution on a dedicated mock-up

Solutions for MDI area

Left side w.r.t right side

- ✓ Monitoring of one BDS w.r.t other
  - Link stretched wires on both side by a common references (like in the LHC), using the survey galleries





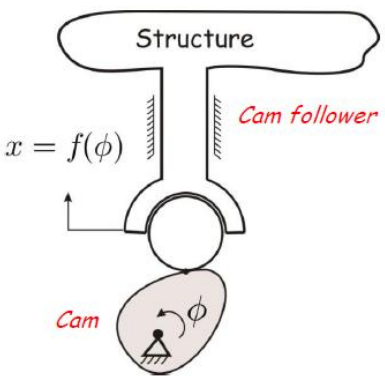
Detector w.r.t BDS geometry

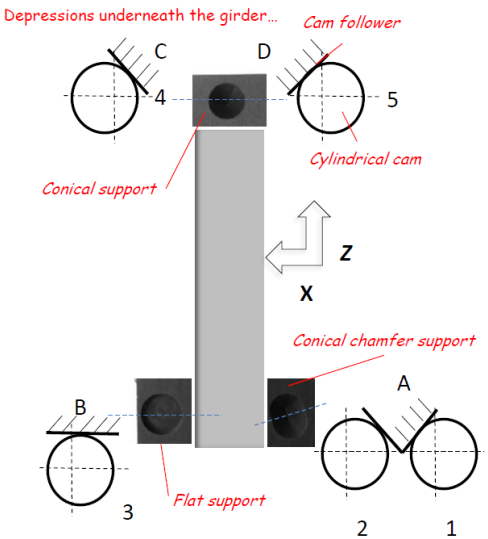
- ✓ Because of push/pull detectors, which will have to be reinstalled and repositioned rapidly and precisely, references from BDS (HLS, WPS sensors or other electro-optical systems) that are located in cavern will be a must.
- ✓ To be further investigated once detectors are more defined

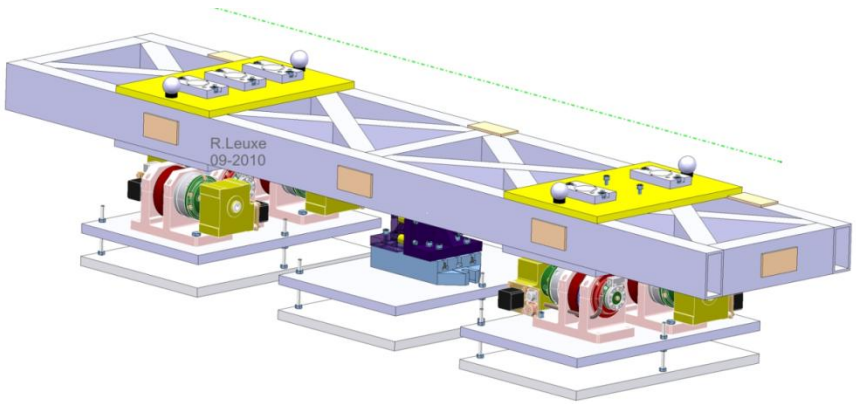
Solutions for MDI area

Adjustment solution

- ✓ Same solution proposed for the MB quadrupole of the main linac
  - Cam movers
  - Remote adjustment of the longitudinal axis using a stepping motor







Next steps

- 5 DOF mock-up ready before end of 2010
- Develop and validate remote longitudinal adjustment (end of 2011)
- Integrate this solution below each component to be pre-aligned

Thank you very much for your attention