QD0 and BDS pre-alignment

H. MAINAUD DURAND

on behalf of the CLIC active pre-alignement team

SUMMARY

- ✓ BDS pre-alignment requirements and strategy
- ✓ MDI area requirements and strategy:
  - Determination of the position of QD0 w.r.t other components of the BDS
  - Left w.r.t right side
  - Monitoring of QD0

BDS: requirements concerning pre-alignment

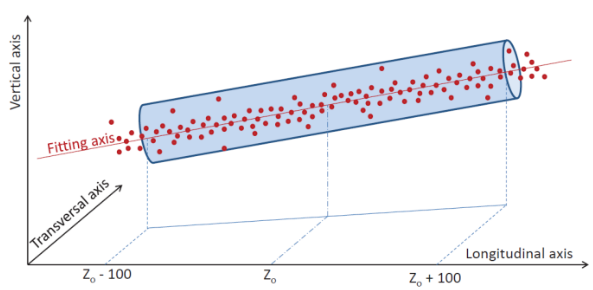
PRE-ALIGNMENT (beam off)

Mechanical pre-alignment → Active pre-alignment → Beam based alignment

Within +/- 0.1 mm (1σ) | Within a few microns | Beam based feedbacks

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

CLIC



The zero of each component will be included in a cylinder with a radius of a few microns:

➔ 10 μm (BDS components)

(14 μm / 17 μm for main linac components)

Adjustment required: step size below 1 μm, 5 DOF

ILC

Error of misalignment of the fiducials (1σ): 0.02 mm over 200 m

Fiducialisation: 0.05 mm rms

BDS: strategy

Solution proposed

Installation and determination of the Survey network

Transfer of reference into tunnel

Installation and determination of the tunnel network

Absolute alignment of the elements

Relative alignment of the elements

Active prealignment

Control and maintenance of the alignment

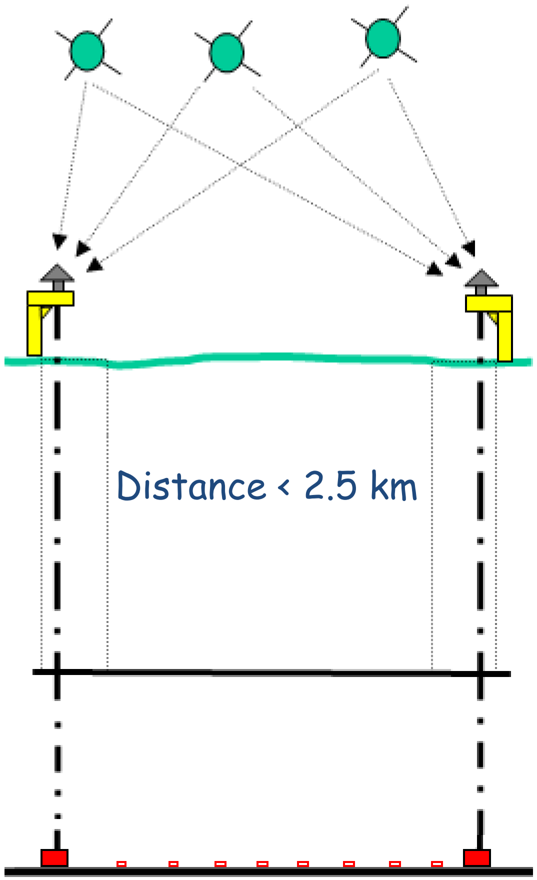
BDS: strategy

Solution proposed

Installation and determination of the Survey network

Transfer of reference into tunnel

Installation and determination of the tunnel network



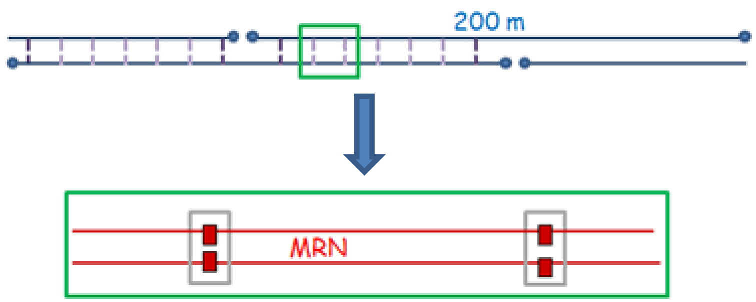
- ✓ Combination of 3D triangulation and trilateration coupled with measurements on vertical plumb wires
- ✓ Methods validated on an LHC pit in 2010 (depth of 65 m): precision of 0.1 mm and accuracy of 0.5 mm
- ✓ Hypothesis considered for CLIC: absolute position at the bottom of each pit: ± 2 mm (depth > 100 m)

BDS: strategy

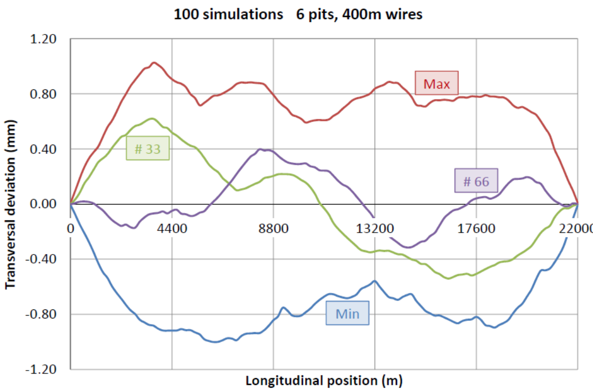
Solution proposed

Absolute alignment of the elements

Relative alignment of the elements

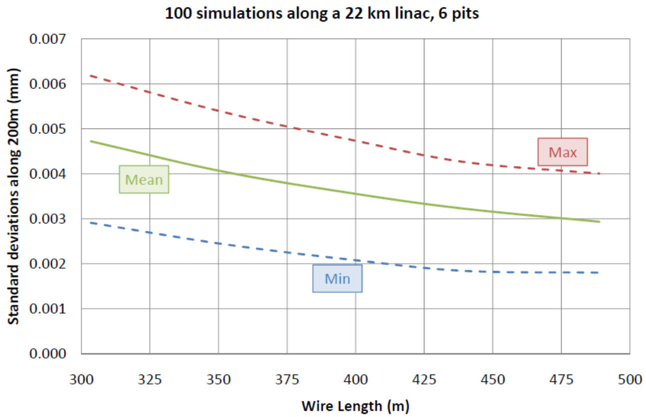


Metrological Reference Network



Propagation network simulations

- ✓ Installed w.r.t the tunnel network
- ✓ Overlapping stretched wires propagating the precision over long distances
- ✓ Simulations in 2009:
  - ○ Precision at the bottom of the shaft of ± 2 mm
  - ○ Calibration of metrological plates: ± 5 µm
  - ○ Distance between pits: 3.5 km
  - ○ Wires: 400m long



Std deviation of 3.6 µm over 200m of sliding window

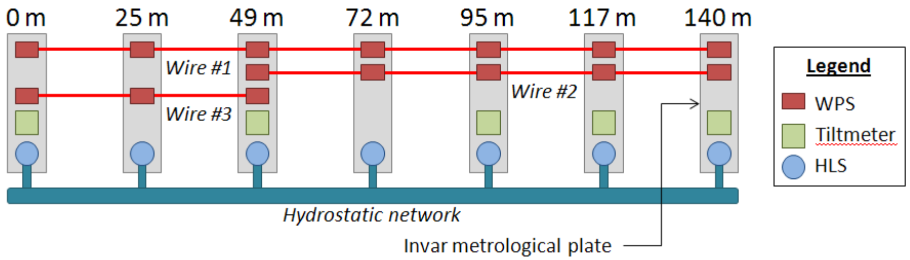
BDS: strategy

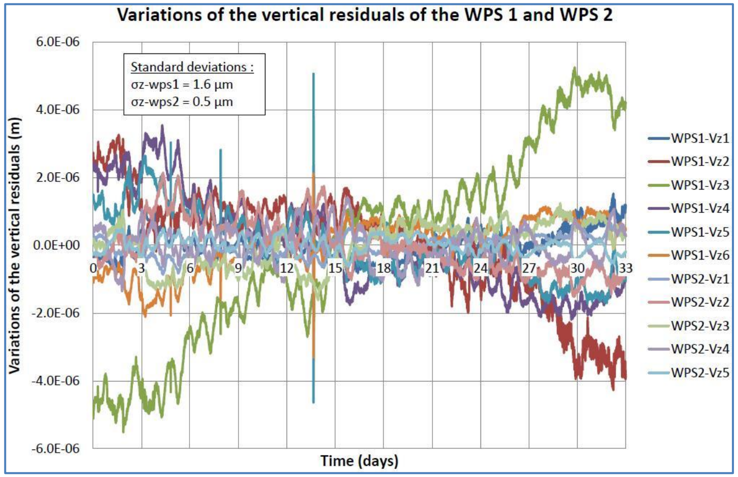
Solution proposed

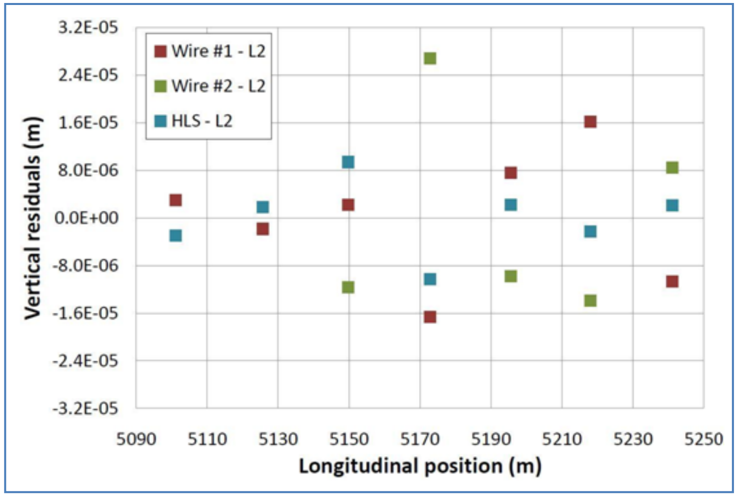
Absolute alignment of the elements

Relative alignment of the elements

TT1 facility







- ✓ Precision on a 140 m wire: better than 2 microns over 33 days
- ✓ Standard error in the determination: 11 microns in vertical, 17 microns in radial. Can be improved!

BDS: strategy

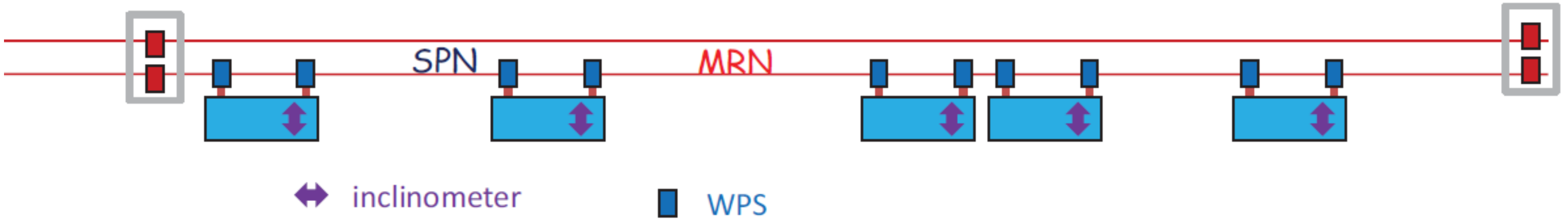
Solution proposed

Absolute alignment of the elements

Relative alignment of the elements

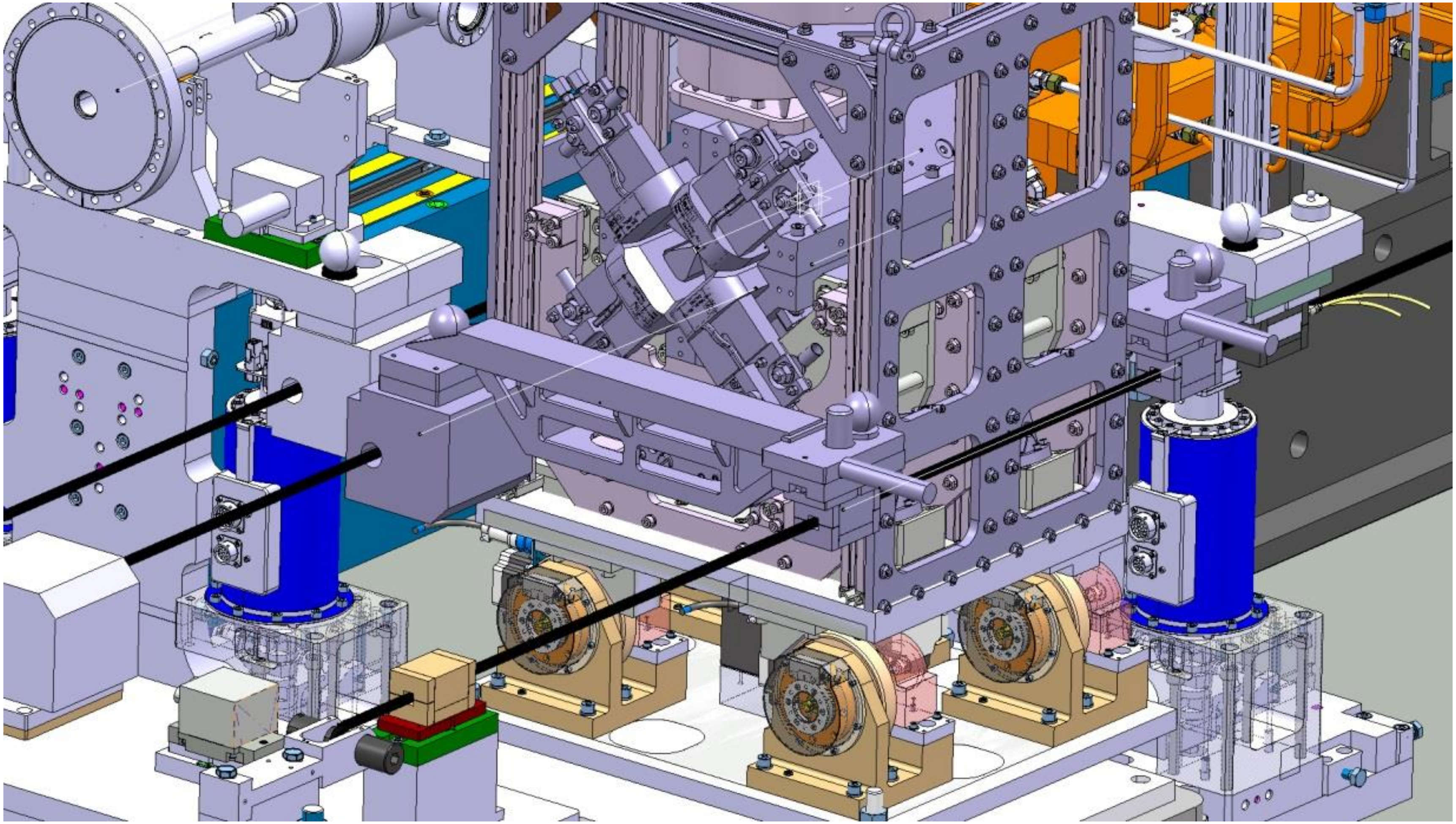
SPN: Support Pre-alignment Network :

- ✓ Sensors that are part to the component
- ✓ Micrometric measurements between zero of the component and sensors interfaces



Active prealignment

Determination of the position



Fiducialisation of components

Fiducialisation of their common support, including stabilization support

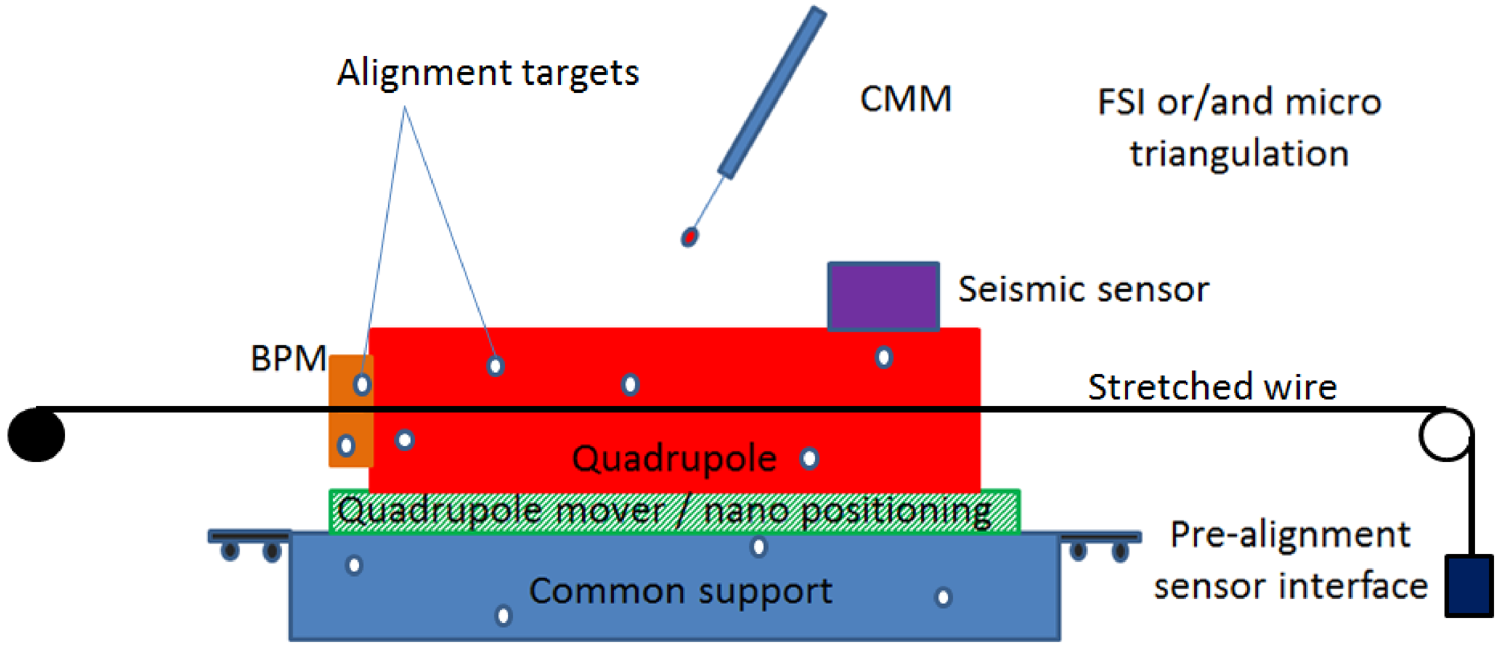
Alignment on a common support

Whole assembly ready to be aligned

Scientific project

PACMAN project:

Propose and develop an alternative solution integrating all the alignment steps and technologies at the same time and location (CMM machine)



Marie Curie Initial Training Network (ITN):

Innovative Doctoral Program

CERN as host institution

10 PhD students

15 associated partners

Start date : 1/09/2013

Duration: 4 years

Web site: http://cern.ch/pacman

Recruitment under way

Cranfield University	GB
ETH Zürich	CH
LAPP	FR
SYMME	FR
University of Sannio	IT
IFIC / FESIC	ES
Delft University of Technology	NL

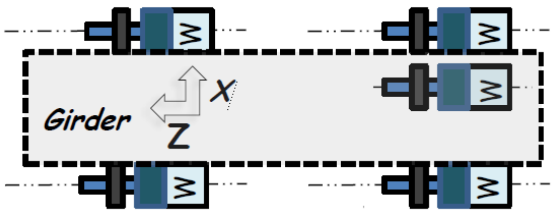
DMP	ES
ELTOS	IT
ETALON	DE
METROLAB	CH
SIGMAPHI	FR

Hexagon Metrology	DE
National Instruments	HU
TNO	NL

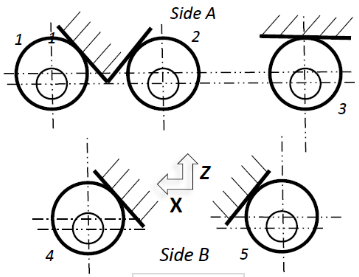
BDS: strategy

Solution proposed | **Active prealignment**

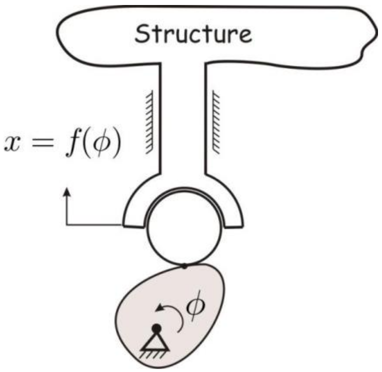
Adjustment with Cam movers

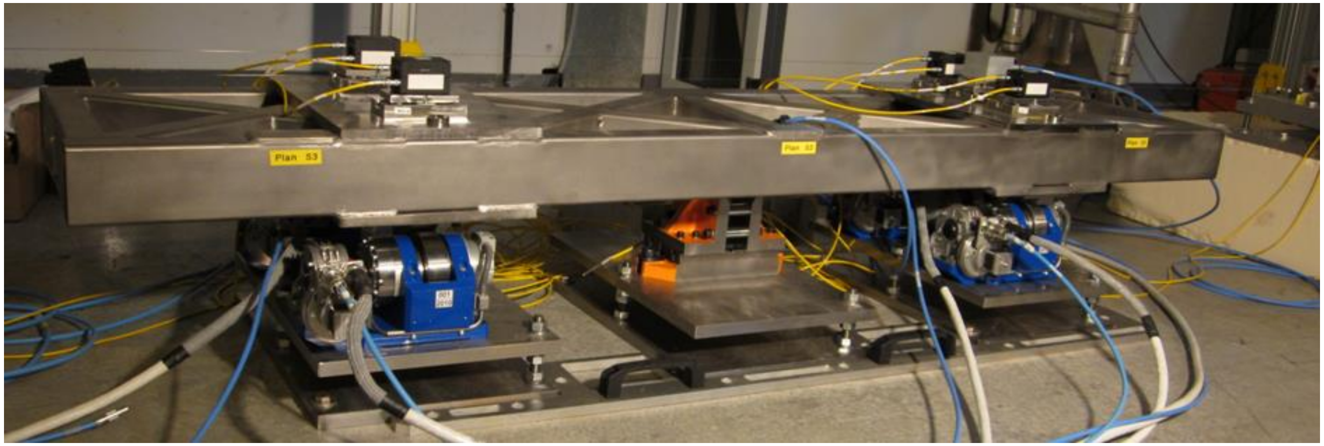


(Base View)



(Front View)





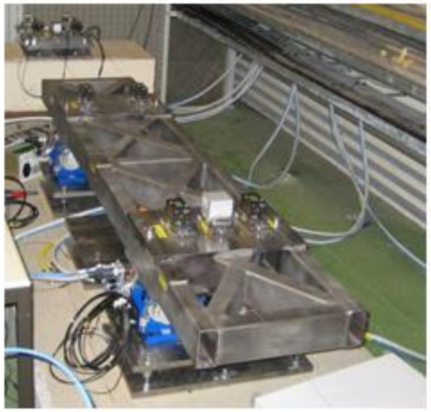
BDS: strategy

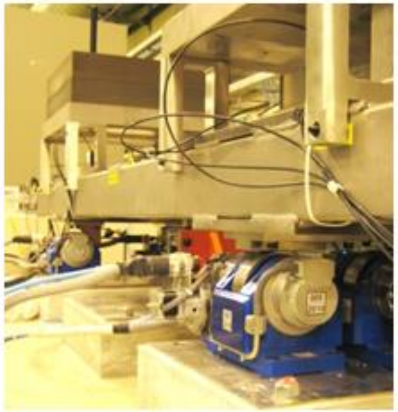
Solution proposed | **Active prealignment** | **Cam movers**

Compact cam mover:

- ✓ Prototype built and installed in 1 DOF test setup
- ✓ Assembly and calibration of cam movers under progress
- ✓ Next step: compatibility with stabilization solution

Standard cam mover:





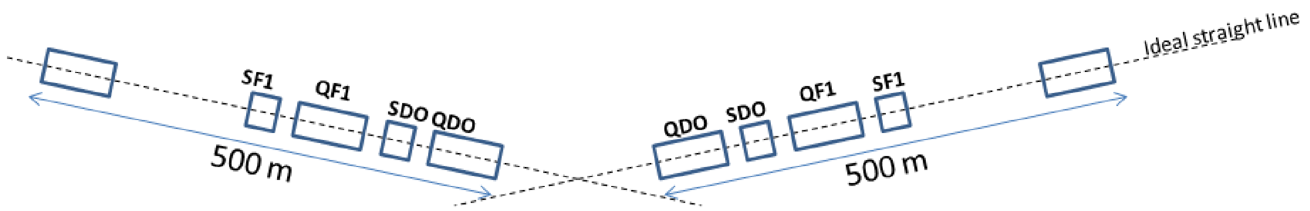
- ✓ Movement resolution < 1 µm
- ✓ Repeatability < 5 µm (radial & vertical translation), 5 µrad (roll)
- ✓ Single displacement accuracy (deviation between required and measured relative orientation):
    - Short & simple movements: 10 -20 µm / µrad
    - Complex movements : >> 10 -20 µm / µrad
- ✓ Displacements accuracy using automatic iteration (target < 1 µm or 5 µrad):
    - Simple movements: 2 - 3 iterations
    - Complex movements: up to 10 iterations

SUMMARY

- ✓ BDS alignment strategy: status and next steps

- ✓ MDI area:
  - Determination of the position of QD0 w.r.t other components of the BDS
  - Left w.r.t right side
  - Monitoring of QD0
  - Detector w.r.t BDS geometry

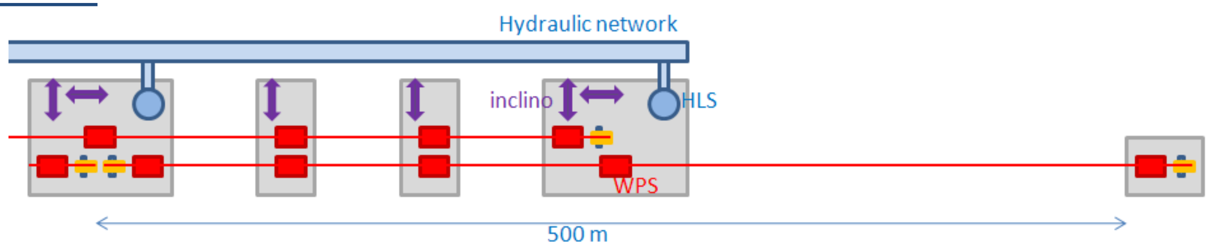
Determination of the position of QD0 w.r.t other components of the BDS (1)



Requirements :

- ✓ Position of the zero of QD0 w.r.t ideal straight line of the 500 last meters of BDS: ± 10 µm rms (including fiducialisation) ➡ also needed for ILC (± 20 µm not including fiducialisation)
- ✓ Longitudinal relative position between QD0 and QF1: ± 20 µm rms

Strategy proposed :



- ✓ Same solution than for 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, which will be extrapolated
- ✓ Longitudinal position: use of sensors (capacitive, LVDT) to follow the relative position.

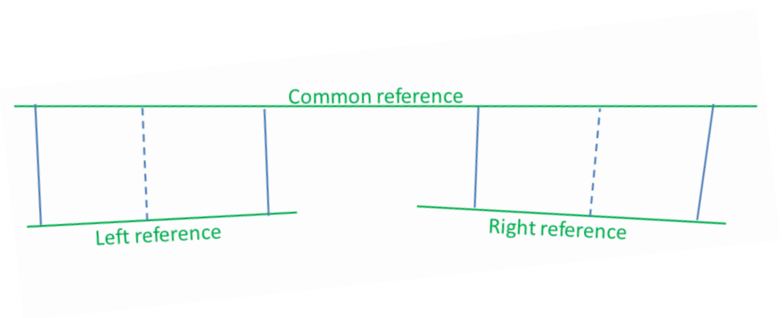
Left side w.r.t right side

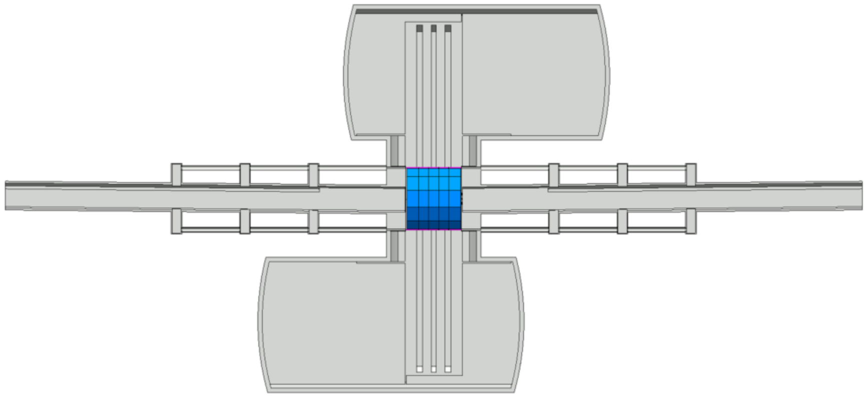
Requirements:

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

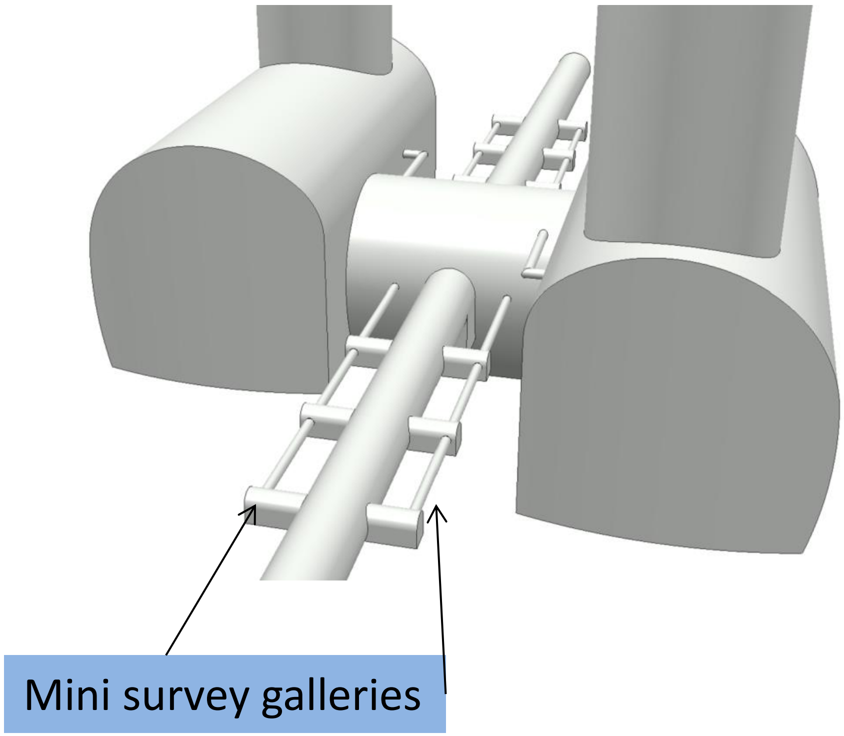
Strategy proposed :

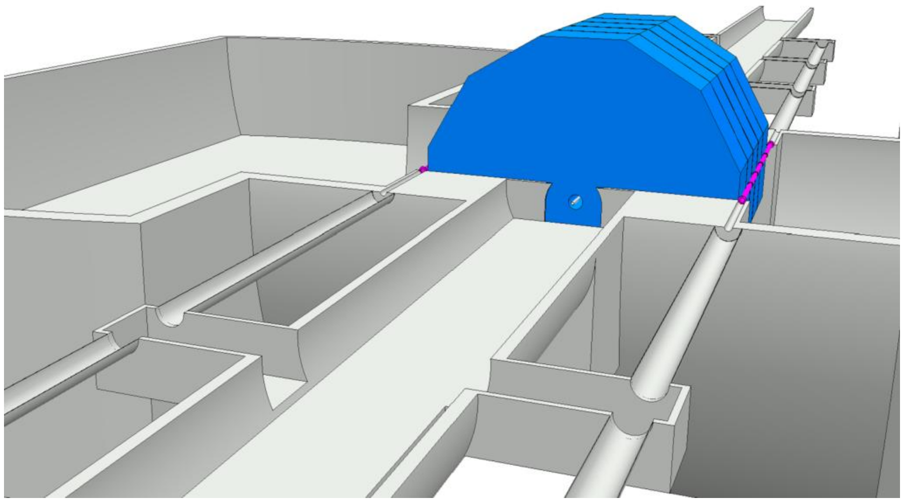
- ✓ Monitoring of one BDS w.r.t other
  - Link stretched wires on both side by a common references (like in the LHC), using the survey galleries





Survey mini galleries



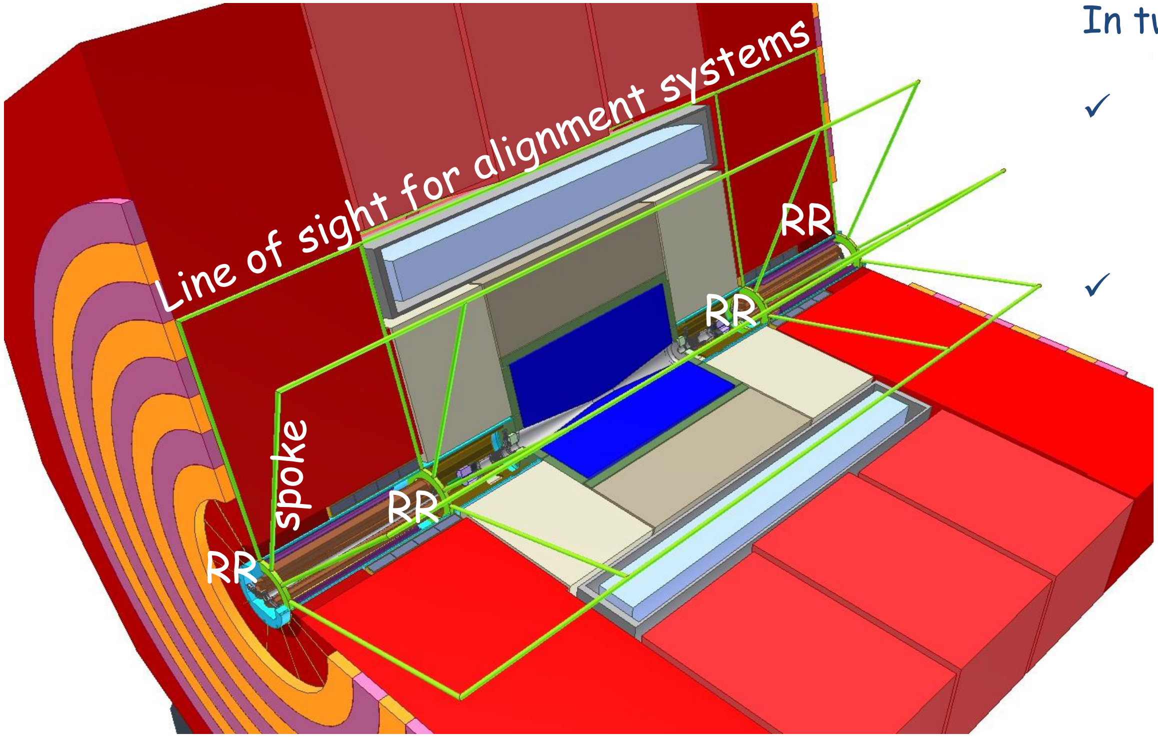


NIKHEF

Left side w.r.t right side

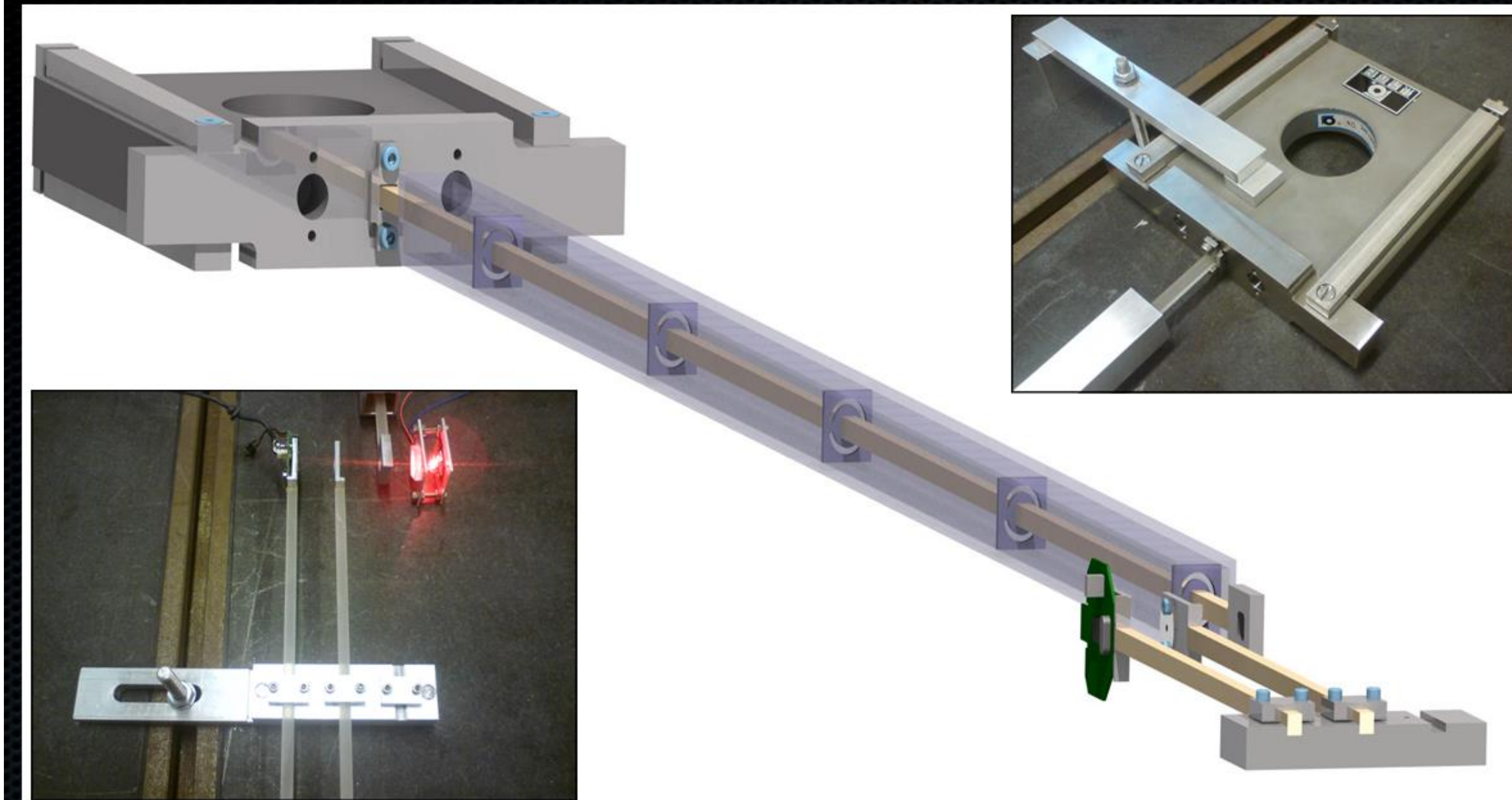
Monitoring of the position of left QD0 /right QD0: Concept

- ✓ 4 Reference Rings (RR) located at each extremity of QD0, supported from outer tube
- ✓ 6 radial spokes per RR



In two steps:

- ✓ A monitoring of the position of QD0 w.r.t RR thanks to proximity sensors. (initial calibration of their position performed on a CMM)
- ✓ A transfer of the position of RR thanks to 6 spokes to alignment systems. By combination of redundant information, the position of the center of 4 RR is computed.



Zerodur 1m spoke test set-up

- ✓ **Transfer quality ~ 0.1 µm (12 dismounting /remounting)**
- ✓ **Thermal expansion driven by granite thermal expansion, and confirm that the thermal expansion of zerodur is very small**
- ✓ **Young modulus checked.**

Summary

In the MDI area, 3 subjects are under study currently, common to CLIC and ILC:

✓ **The monitoring of the position of QD0, through a collaboration with NIKHEF**
  - Concept proposed
  - First tests performed on 1m long spokes
  - Sensors under validation on TBTM

✓ **Survey mini galleries**
  - Concept proposed

✓ **The improvement of the fiducialisation process via PACMAN**
  - 10 PhD students will start to work on the project beginning of 2014

In the BDS area, taking into consideration the very tight alignment tolerances for ILC, an active alignment will be needed. The solution proposed for CLIC could be applied:

✓ Determination of the position of components using alignment sensors

✓ Re-adjustment using cam movers.