PRE-ALIGNMENT SYSTEMS

CLIC Two beam Module Review

Input from Thomas Touzé, Friedrich Lackner, Luca Gentini, Alexander Samoshkin

Hélène MAINAUD DURAND, BE/ABP/SU, 15/09/09

CLIC Pre-alignment requirements

PRE-ALIGNMENT (beam off)

Mechanical pre-alignment

Within +/- 0.1 mm (1σ)

→ Active pre-alignment

Within ± 10 μm (3σ)

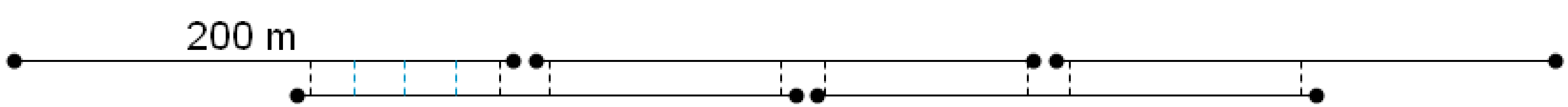
→ Beam based alignment
Beam based feedbacks

A scale order:
For the LHC: ± 0.1 mm over 100m (1σ)
For the ILC: ± 0.2 mm over 600m (1σ) (vertical direction)

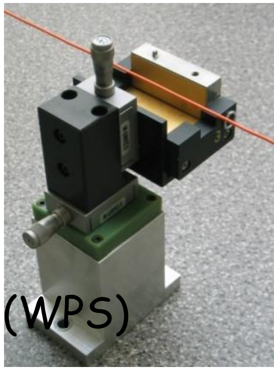
CLIC active pre-alignment
=
technological challenge

General pre-alignment concept

- ✓ Straight alignment reference over 20km consists of overlapping references



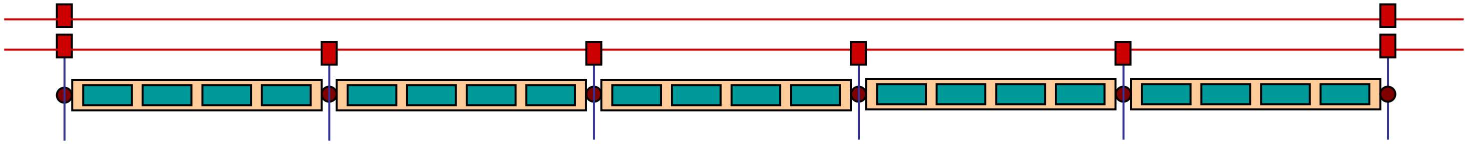
Favoured pre-alignment concept



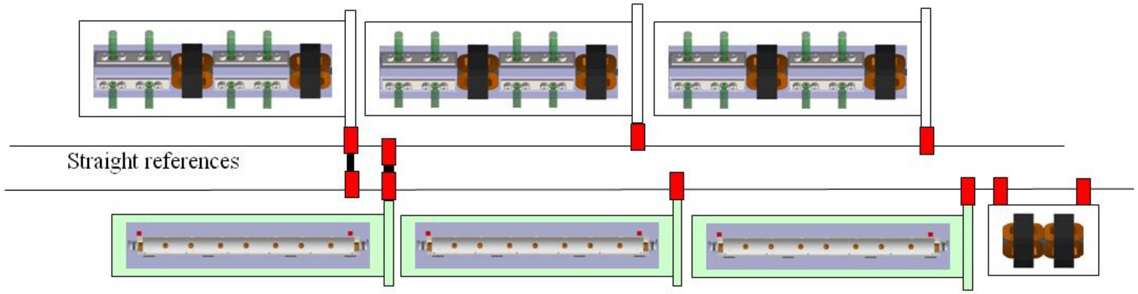
- ✓ straight reference = stretched wire
- ✓ vertical & transverse position measured thanks to Wire Positioning Sensors (WPS)

Accelerating structures
PETS + DB quad } pre-aligned on independent girders

- ✓ DB and MB girders pre-aligned with 3+1 DOF (« snake system » / “articulation point”)



- ✓ MB quad pre-aligned independently with 5+1 DOF



Feasibility of the concept

The feasibility is proved if one can demonstrate:

- A stable alignment reference, known at the micron level
- Sub-micrometric sensors
- A mechanical/electrical zero of each sensor perfectly determined with respect to the reference of the component to be aligned
- The compatibility with the general strategy of installation and operation
- The compatibility with the other accelerator equipment or services.

➔ Implementation of a R&D strategy in order to prove the feasibility of the pre-alignment solution, reviewing each key point carefully.

➔ Validation foreseen on mock-ups before CDR

➔ Validation foreseen with beam in CLEX in 2012.

Feasibility of the concept

Review of one key point → the compatibility with the module of the pre-alignment solution:

- Integration of the pre-alignment systems
- Installation considerations
- Design of the re-positioning systems
- Fiducialisation
- Validation on mock-ups

The key issues concerning the definition of the wire as a reference and sensors are not covered in that talk.

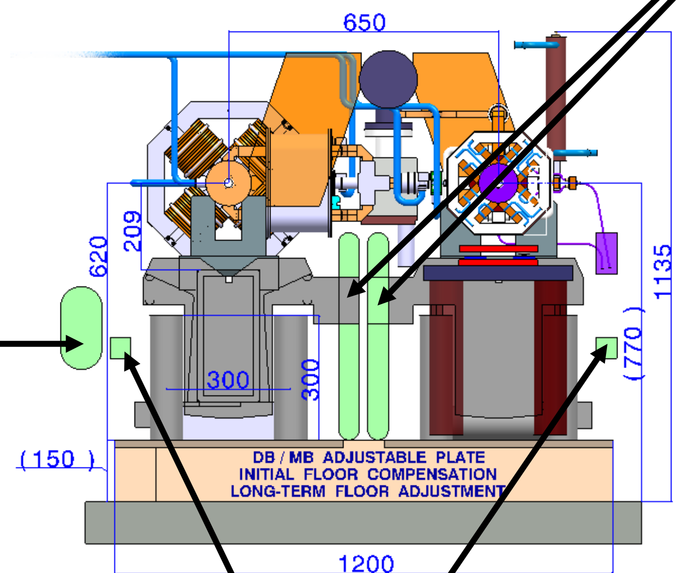
Key point→ compatibility with the module

Issue: integration of the pre-alignment systems

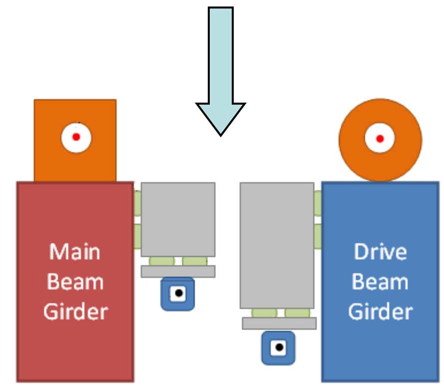
WPS system

(follows the slope, but the wire has a sag)

HLS system (horizontal)

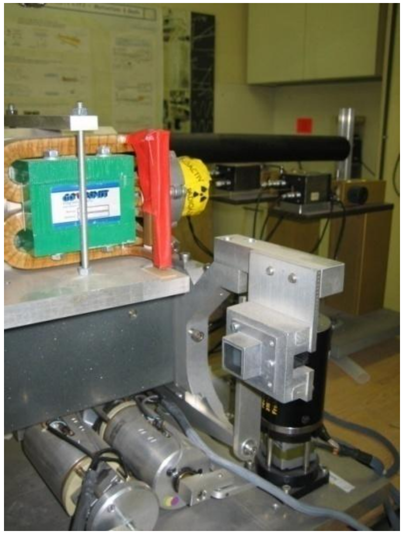


(Alexander Samoshkin)



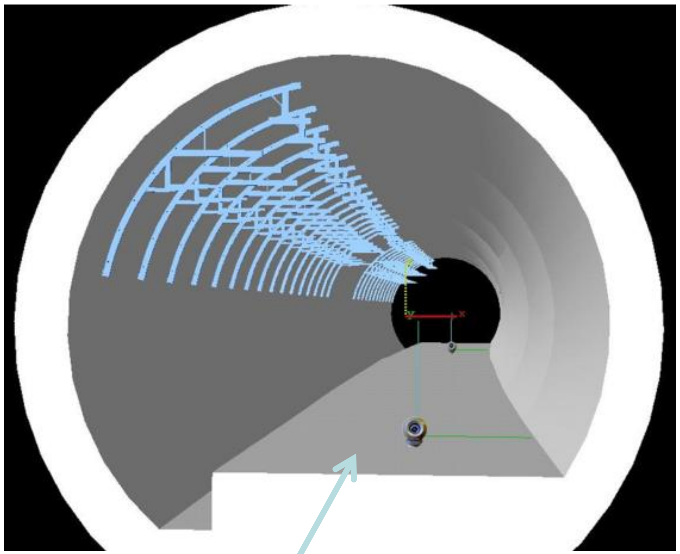
(Thomas Touze)

Proximity sensors (RASNIK), mechanically linked to each cradle

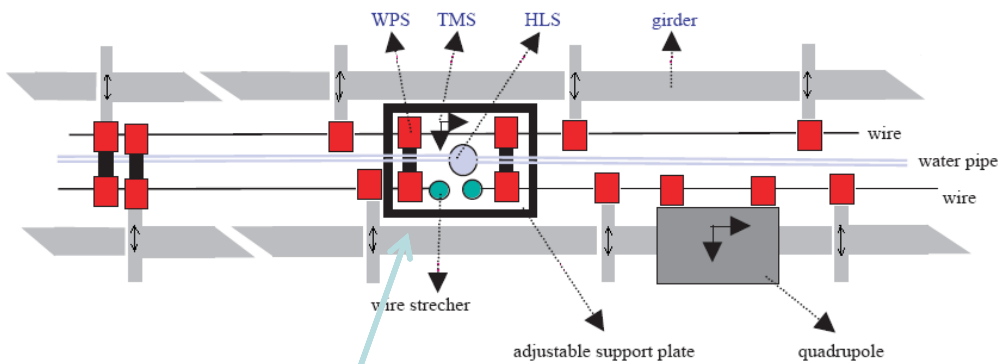


Issue: installation considerations

- ✓ The propagation network must be installed and determined at the beginning, once the geodetic network is known. (to allow a positioning of actuators and sensors within their range)



Geodetic network

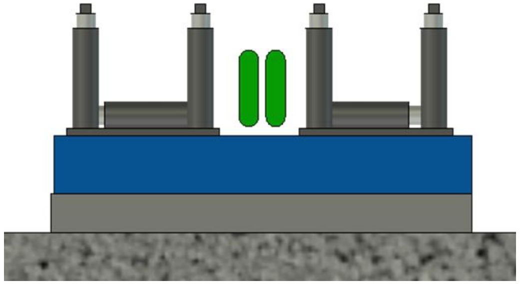


Metrological plate

The metrological network consists of overlapping stretched wires and metrological plates (every 100 m if the wire length is 200 m)

Issue: installation considerations

- ✓ For each module, an adjustable plate with the actuators will be installed and pre-aligned w.r.t this metrological network



(Alexander Samoshkin)

- ✓ Once the module (or MB quad) is in place, its relative alignment is performed w.r.t the metrological network
  ➔ the joining of the interconnection is possible

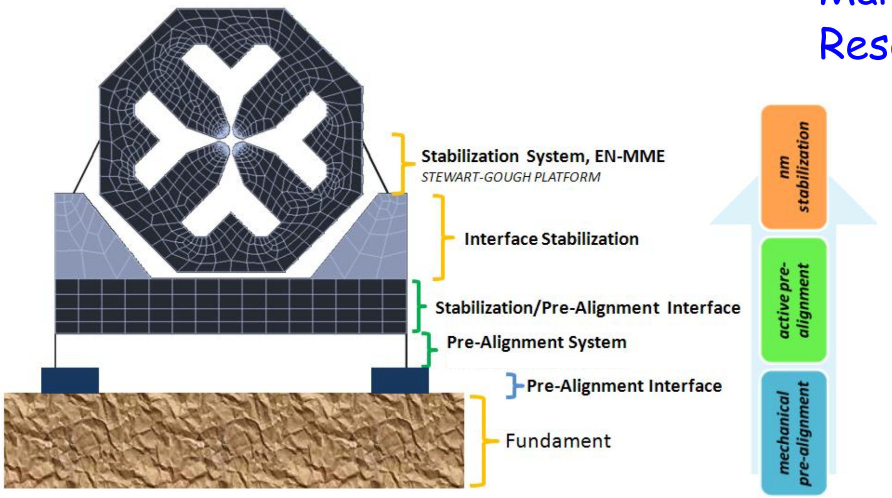
- ✓ Once all the modules in a sector (pit to pit) are installed, the positions of the elements are computed
  ➔ pre-alignment of the modules (and MB quads)

- ✓ Once no more access in the tunnel, implementation of the active pre-alignment

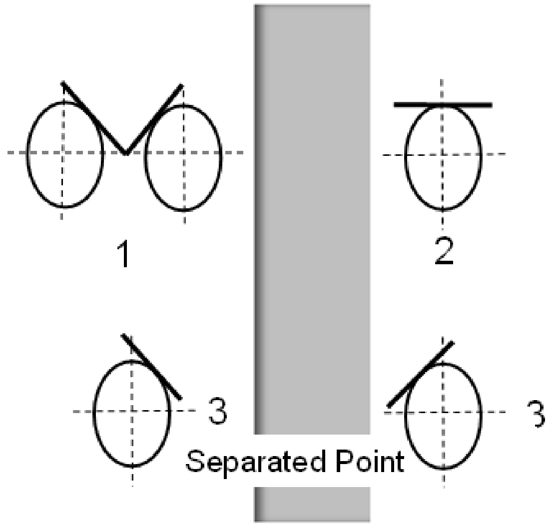
Issue: design of the re-positioning systems (1)

✓ Case of the MB quad:

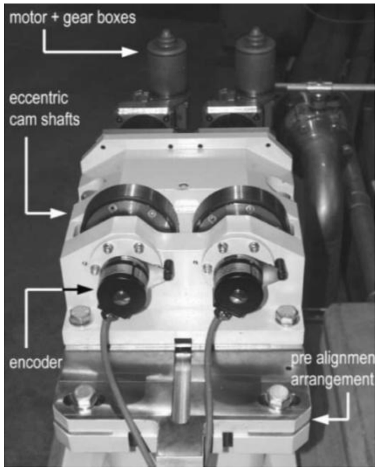
Motorized pre-alignment: 5 DOF, +/- 3 mm
Manual initial pre-alignment: 6 DOF, +/- 10 mm
Resolution: 1 μm



(Friedrich Lackner)



(PSI SLS cam configuration)



- 3 point support
- 4 interfaces with fundament
- 5 cams

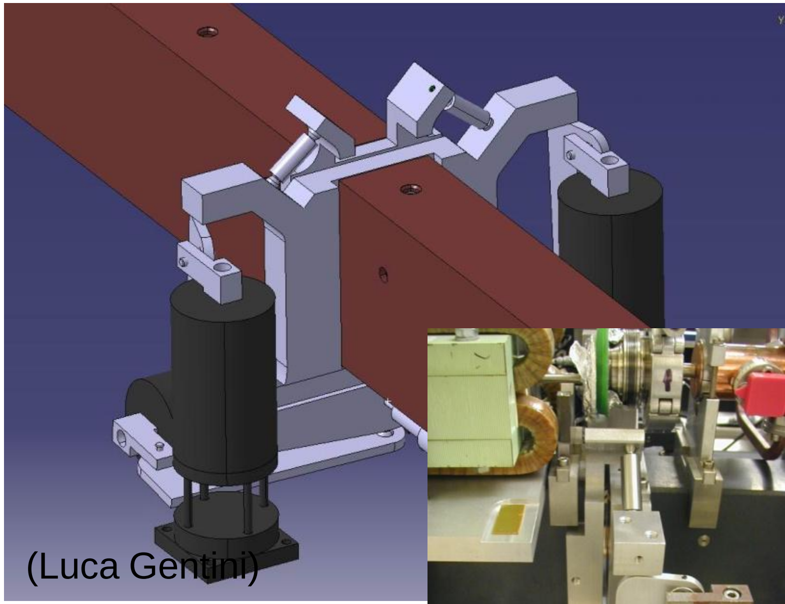
Issue: design of the re-positioning systems (2)

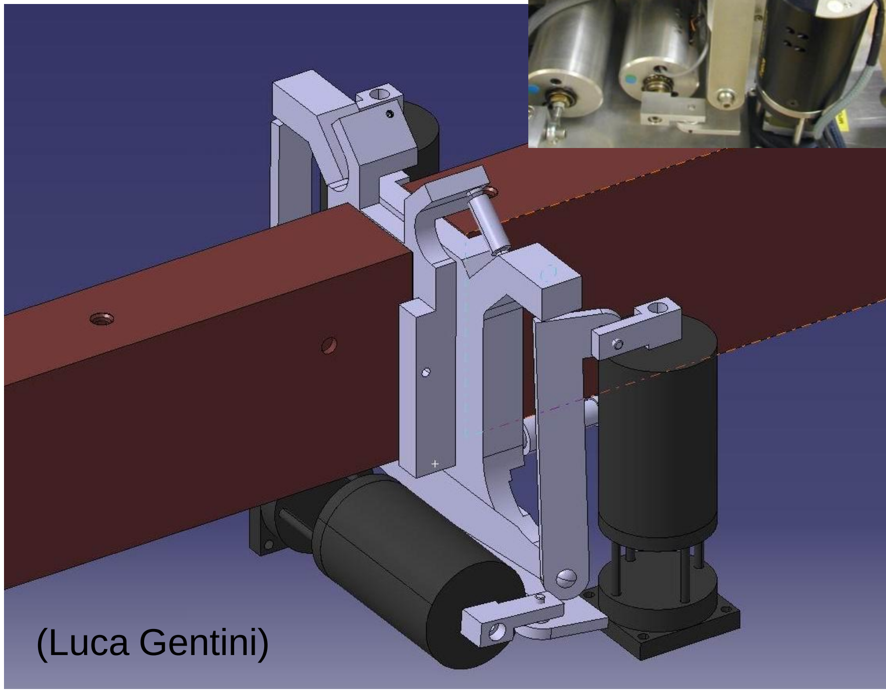
✓Case of the DB and MB girders:

- "CTF2 concept", validated in CTF2, with beam

But:

- Resizing needed (higher loads)
- Actuators not on the shelf
- Stability with CAS requirements TBC
- kinematics (14 bearings)
  - ➔ internal friction
  - ➔ clearances
  - ➔ transmission between girders


(Luca Gentini)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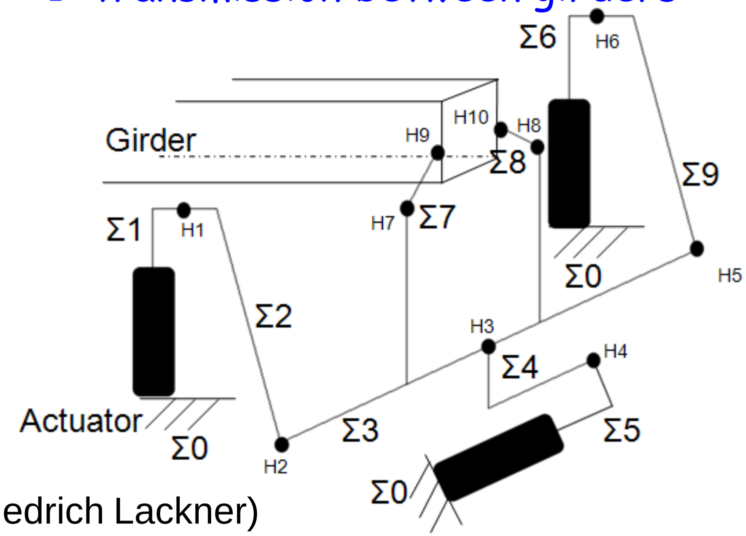


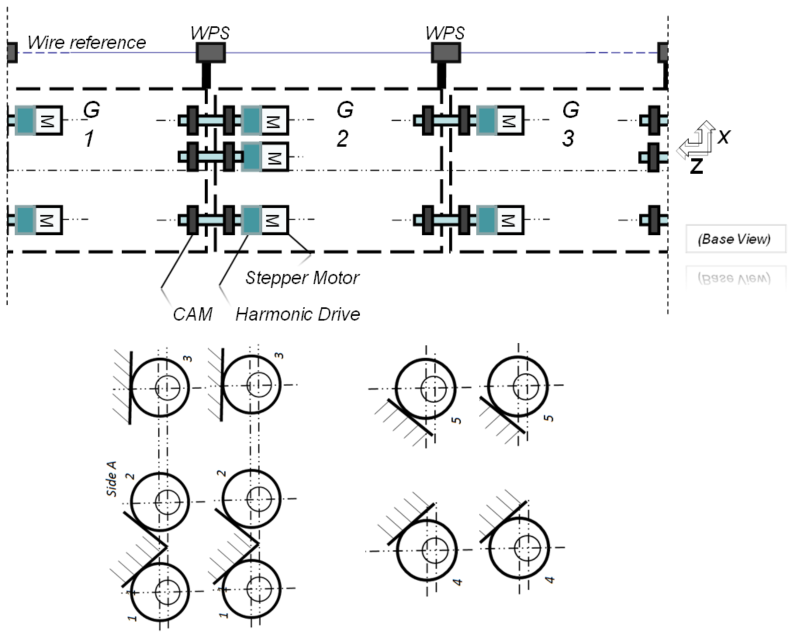
(Friedrich Lackner)

One alternative: articulation point with cam system (instead of linear actuator)

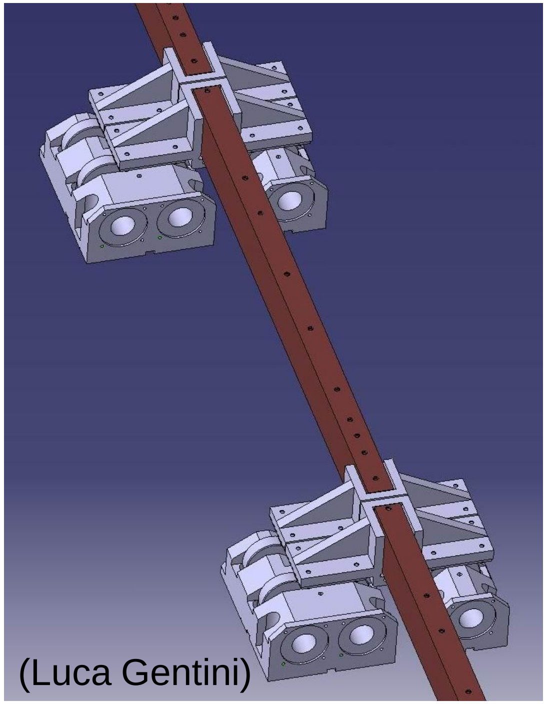
- Better kinematics

But:

- Resolution to improve
- Contact design the improve (high contact stress due to contact point)
- Stability?



F. Lackner - Girder Alignment – 02.09.2009



Issue: design of the re-positioning systems (3)

✓ Conclusion

- Cam system very promising but not mature yet for the re-positioning of the girders
  - ➔ Keep the CTF2 concept for the CDR
  - ➔ Test and improve the cam system in parallel

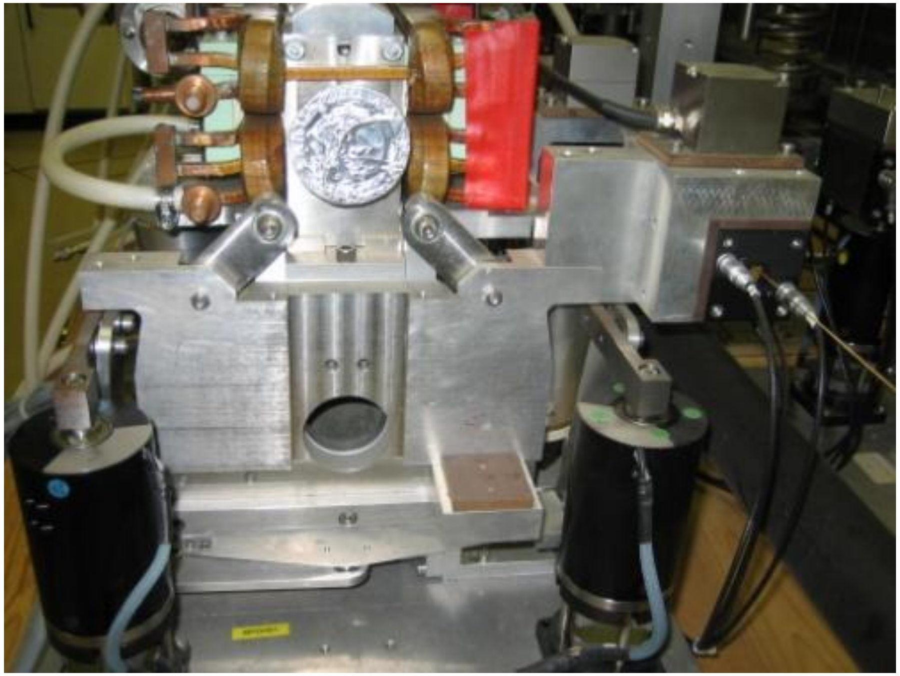
- Before the CDR, it is needed:
  - ➔ To test the old CTF2 mock-up and find a solution concerning the transmission between 2 girders
  - ➔ To validate the CTF2 upgraded solution on a 2 girder / 3 articulation points configuration.

- To re-direct the studies post CDR, it is needed to start ASAP the studies concerning the cam system:
  - ➔ Exchange of information and drawings with SLS
  - ➔ Test the SLS solution for the MB quad
  - ➔ Improve that solution (resolution)
  - ➔ Design a solution for the articulation point and test it.

Issue: fiducialisation

We need to demonstrate the MB quad and girder pre-alignment strategy, e.g: it is possible to position the zero of the MB quad and girder w.r.t. a straight line within a few microns.

➔ What is the zero (mechanical, magnetic, RF)?
➔ How is it determine w.r.t external pre-alignment references
➔ Find the best design, implantation, configuration for these external pre-alignment references (stability during time, impact of thermal variations)
➔Validation of the solution on a mock-up.



Issue: validation on mock-ups

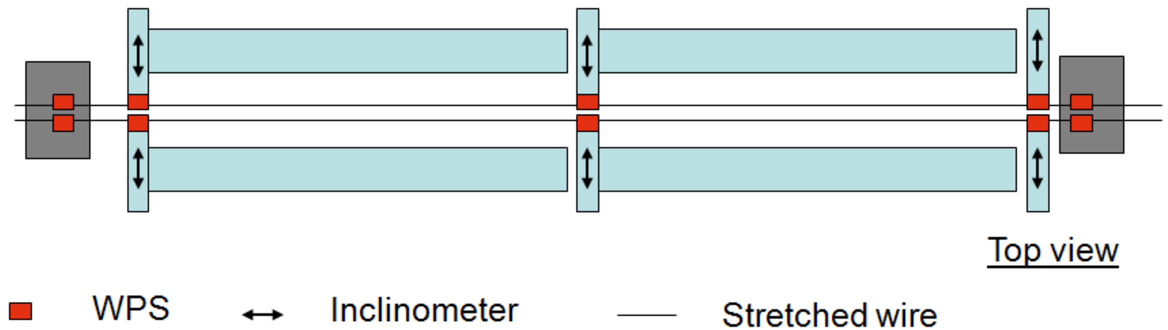
✓ Phase 1: before the CDR

→ Case of the MB quad:

- a type 4 mock-up will allow to test and validate the cam system as re-positioning solution, as well as the fiducialisation strategy.

→ Case of the girders:

- o on the old CTF2 setup :test of the transmission of displacement between girders
- o on a 2 girder / 3 articulation points mock-up : test and validation of the improved CTF2 solution
- o on a 2 girder / 3 articulation points mock-up : test and validation of the cam system solution



➔ Each girder equipped with false PETS, DBQuad and CAS (real load)

➔ Interconnections + waveguides to add

Objectives of the mock-ups:

- Validation of the mechanical concept
- Measurement of the eigenfrequencies of the girders
- Validation of the fiducialisation strategy
- Possibility of micrometric displacements with waveguides and interconnections
- Validation of the stability of the components on the girders:
  - → Impact of the transport on a micrometric pre-alignment.
  - → Impact of variation of temperature, thermal cycles.
- Assembly of the different mock-ups (type 0 and type 4)
- Preparation of the components for CLEX (work under severe environment): change of the encoders, stepper motors, sensors cables,…

Some first ideas concerning ressources and material needed

- Additional ressources needed [*full time*]:
  - o one mechanical engineer (fellow CLIC?)
  - o one SU engineer (fellow CLIC?)
  - o one FSU (electronics)
  - o one designer in the design office

- Cost:
  - o Pool of sensors (inclinometers, WPS, Temp probe) → 100 kCHF
  - o Linear actuators + mechanics → ~ 20 kCHF / system (including command)
  - o Cam based system → ~ 20 kCHF / system (including control/command)

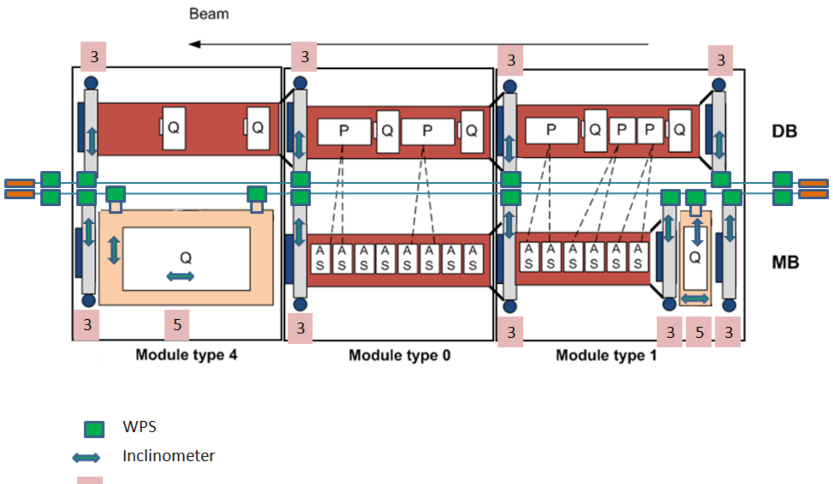
Number of actuators needed:

-Module 1: 20

-Module 0: 6

-Module 4: 11 (6 + 5 MB quad)

Test Modules 104 in CLEX



Source: diagram from Germana (29/07/09), modified (12/09/09)

Conclusion (1)

Thanks to these mock-ups, the feasibility of the pre-alignment strategy for the module (repositioning + fiducialisation) will be validated. We will have a better idea concerning the cost.

Schedule very tight → "Green light" must be given ASAP concerning:

- mock-ups
- additional ressources
- additional budget

A lot of points must be clarified:

- the general schedule and strategy
- find a place for the mock-ups with conditions allowing to perform micrometric measurements
- the pre-alignment requirements (fiducialisation w.r.t to what?, stability requirements for the articulation point, speed of repositioning)
- the working conditions and space foreseen in CLEX.
- what happens after the CDR?

Conclusion (2)

One alternative → a common girder for the DB and MB

From the pre-alignment point of view:

- less sensors and actuators
- constant distance between the two linacs
- alignment systems could be on the MB side, no more in the middle of the two linacs → the distance between the 2 linacs could be decreased

Some question marks:

- coupled beams ?
- integration of the MB quad, while keeping the DB continuity?