CLIC SURVEY AND ALIGNMENT

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OVERVIEW

- ✓ INTRODUCTION – alignment requirements
- ✓ SURVEY AND ALIGNMENT GENERAL CONCEPT
- ✓ PRE-ALIGNMENT STUDY STATUS
  - A known and stable alignment reference
  - Sub-micrometric sensors
  - Fiducialisation and internal metrology
- ✓ CONCLUSION

STRATEGY OF CLIC ALIGNMENT

- Mechanical pre-alignment

→ Within +/- 0.1 mm (1σ)

- Implementation of active pre-alignment

→ Girders and quadrupoles within ± 10 μm (3σ)

- Implementation of beam based alignment

→ Active positioning to the micron level

- Implementation of beam based feedbacks

→ Stability to the nanometer level

PRE-ALIGNMENT REQUIREMENTS

- The tolerance of the transverse pre-alignment of the CLIC components is:

  ± 10 microns (3σ) on a 200msliding window along each linac

- At the micron scale: this pre-alignment needs to be active (ground motion, noise of accelerator environment, temperature dilatations)

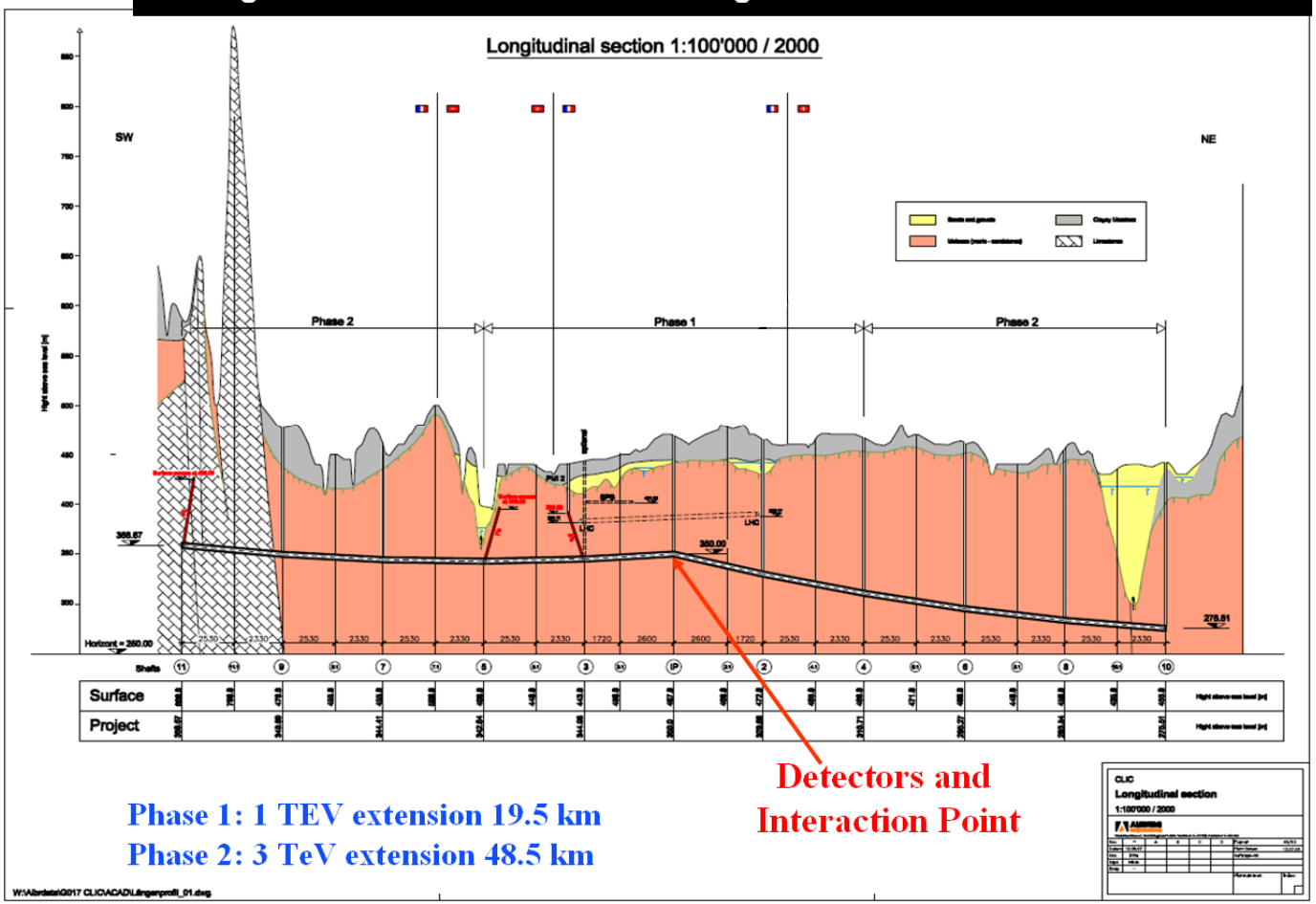
  → continuous monitoring of the position and re-adjustment when necessary.

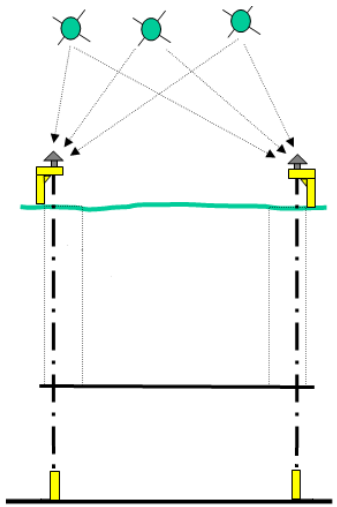
- A scale order concerning this pre-alignment :
  - For the LHC: ± 0.1 mm over 100 m (1σ)
  - For the ILC: ± 0.2 mm over 600 m (1σ) (in the vertical direction)

CLIC pre-alignment = technological challenge

GENERAL ALIGNMENT CONCEPT

Longitudinal section of a laser straight Linear Collider on CERN site–





GENERAL ALIGNMENT CONCEPT

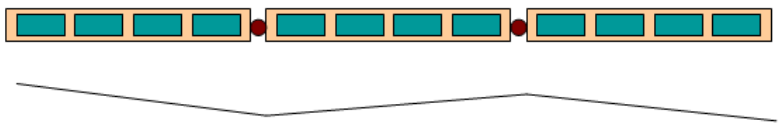
- As it is not possible to implement a straight alignment reference over 20 km: use of overlapping references

- Two references under study:
  - a stretched wire
  - a laser beam under vacuum

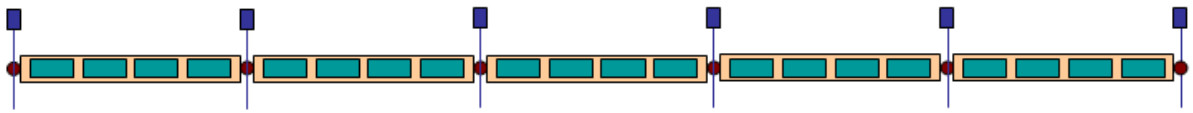
GENERAL ALIGNMENT CONCEPT

- Simplification of the problem by prealigning components on girders

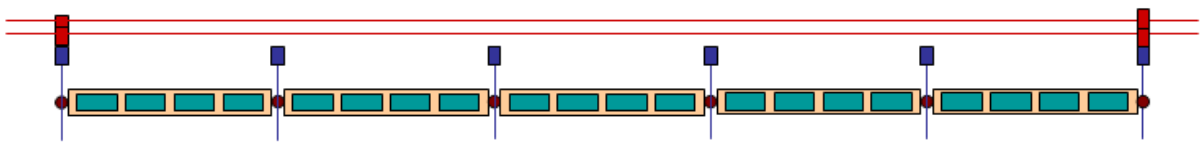
- Simplification of the alignment by linking adjacent girders by a common articulation point



- Association of a « proximity network » to each articulation point



- Association of a « propagation network » to every x articulation point



GENERAL ALIGNMENT 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

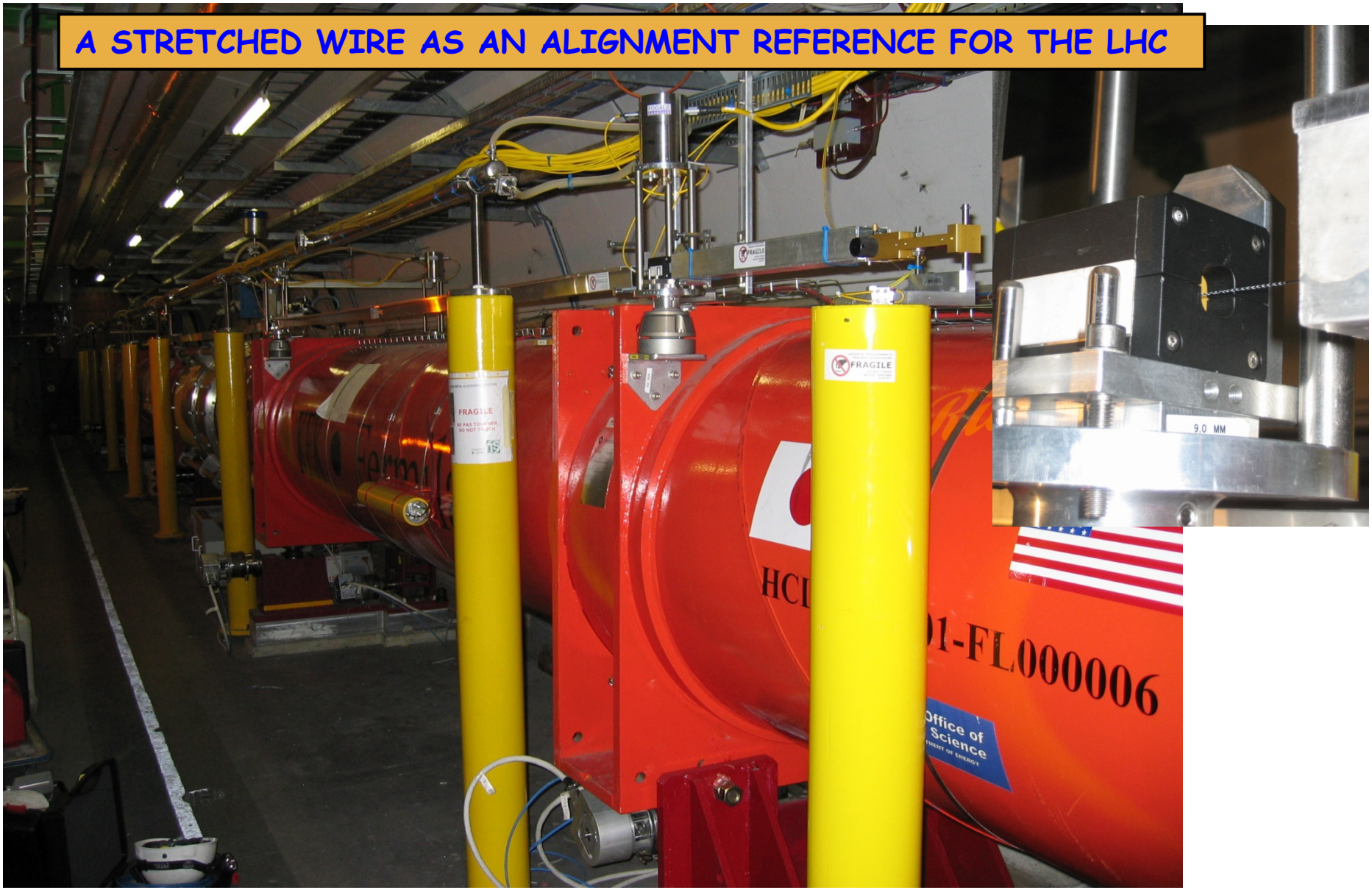
This solution of pre-alignment must be compatible with the general alignment strategy, and with the other accelerator equipment or services.

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

PRE-ALIGNMENT STUDY STATUS

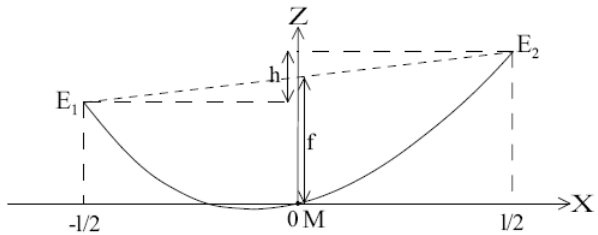
- A known and stable alignment reference
- Sub micrometric sensors
- Fiducialisation and internal metrology


A STRETCHED WIRE AS AN ALIGNMENT REFERENCE FOR THE LHC


A STRETCHED WIRE AS AN ALIGNMENT REFERENCE FOR THE LHC
FRAGILE
9.0 MM
01-FL000006

A STRETCHED WIRE AS AN ALIGNMENT REFERENCE

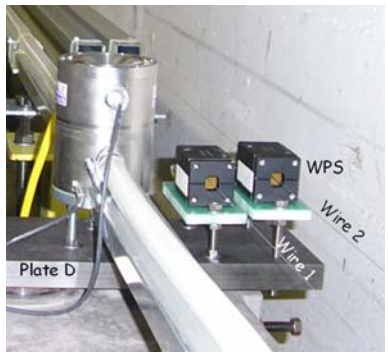
On the scale of a micron, the stability and the determination of the shape of the wire are far more difficult to reach.



$$Z = \frac{4f}{l^2}\left(X + \frac{lh}{8f}\right)^2 - \frac{h^2}{16f}$$

Among the parameters that can contribute to variation in the shape of the wire:

- ✓ Gravity change, function of:
  - ✓Wire location
  - ✓Distribution of the masses in the neighborhood
  - ✓Attraction of the moon and the sun
- ✓ Effect of the rotation of the Earth
- ✓ Weather report (humidity, temperature)
- ✓ Air currents



TT1 TEST FACILITY

First results:

- Good knowledge concerning the installation of long stretched wires
- Great impact of humidity variations on the lineic mass of a wire (and on the sag), but we know how to correct it
- Very good uncertainty of measurement between sensors along 2 wires of different length (100 m and 140m):

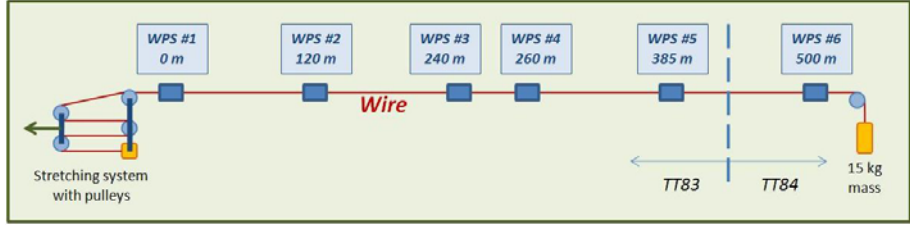
  → 0.4 μm (radial) and 0.6 μm (vertical) over 2 days (stable conditions)

Next steps: an upgrade of the facility

- To confirm the effect of the rotation of the Earth
- To modelize the vertical shape of a stretched wire without the HLS system

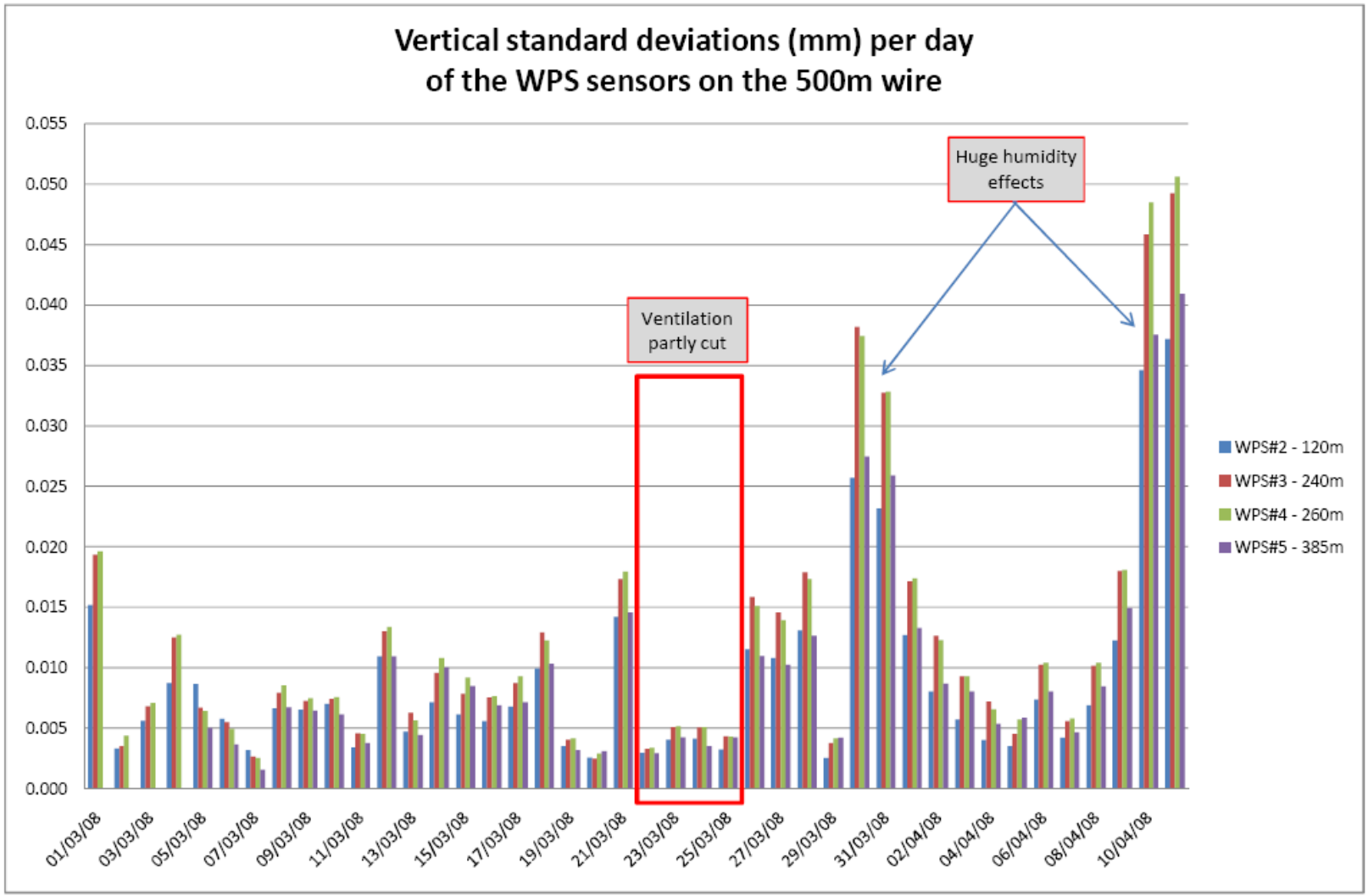
Why not to try to stretch longer wires, in order to decrease the propagation error along the linac?

500 m TEST FACILITY



CERN TS/SU-MTI

Thomas TOUZE



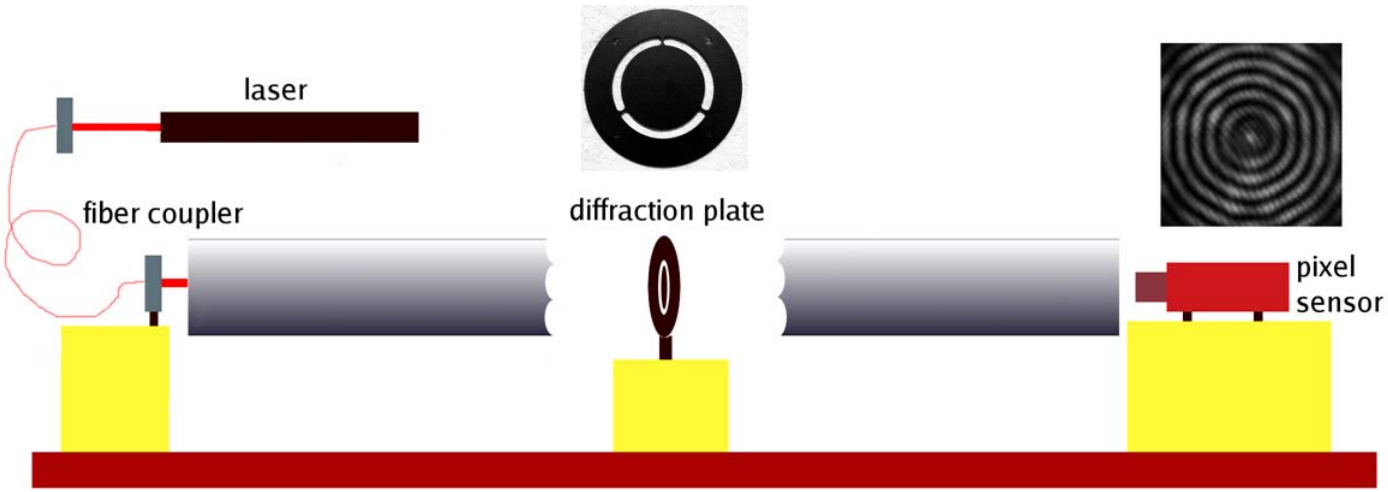
A STRETCHED WIRE AS AN ALIGNMENT REFERENCE

Next studies and tests…

- To obtain a better knowledge of the parameters that influence the shape of the wire
- Study the influence of the gravity changes on a stretched wire and on the leveling system (foreseen for the modelization of the shape of the wire)
- Gravimetric studies have been undertaken concerning the accuracy which can be obtained concerning the determination of the geoid.

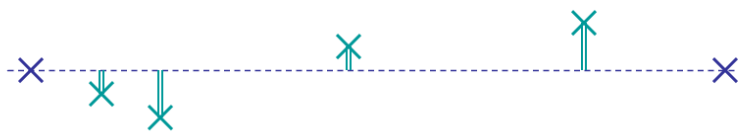
Alternative solution: development of an laser based alignment solution, in collaboration with NIKHEF.

AN OTHER ALIGNMENT SYSTEM: RasCLIC



- Sub micrometric resolution
- Low frequency seismograph.

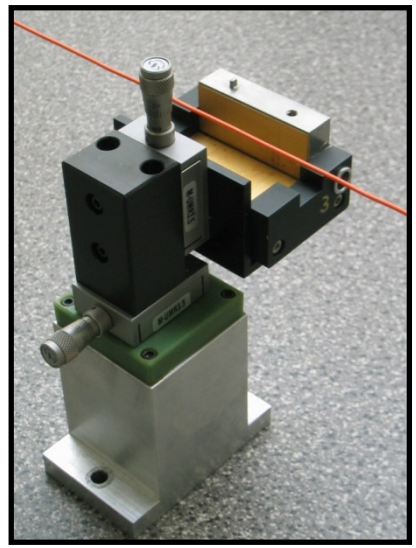
➔ Problem: how to use it for the CLIC pre-alignment?



PRE-ALIGNMENT STUDY STATUS

- A known and stable alignment reference
- Sub micrometric sensors
- Fiducialisation and internal metrology

SUITABLE SENSORS



What is needed:

- A sub micrometric resolution
- A known and controlled drift
- A good interchangeability and a suitable mechanical interface
- Repeatability of measurement better than the micron

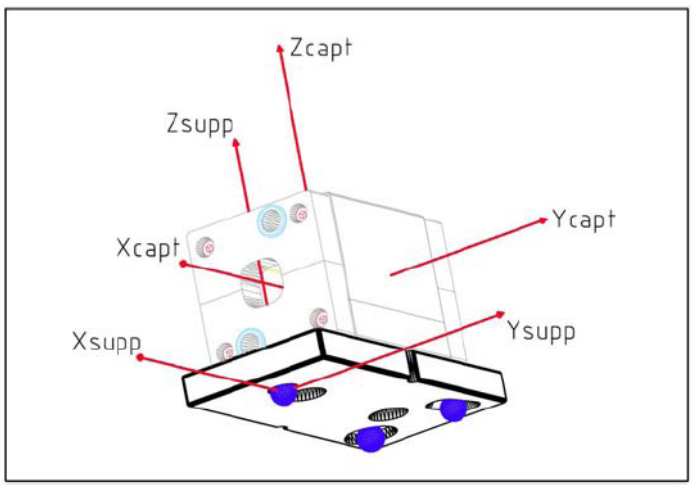
→ Upgrade of the existing capacitive-based WPS sensors

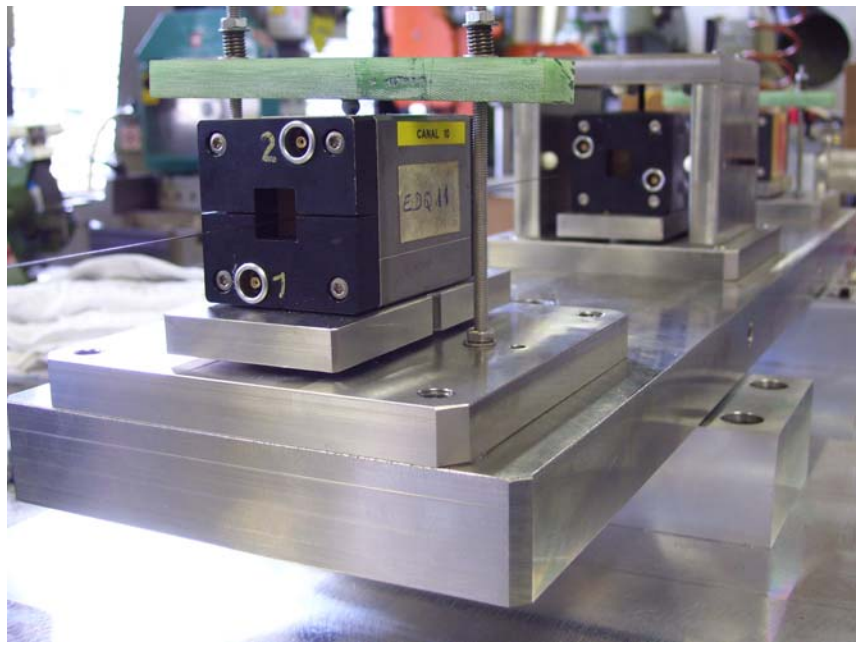
→ Development of an optical -based WPS sensor

SUITABLE SENSORS

Upgrade of the existing capacitive-based WPS sensors

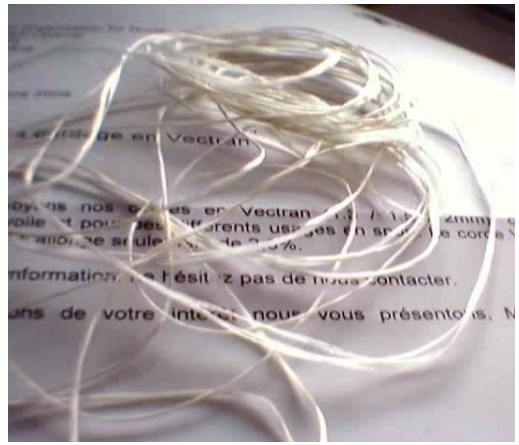
- A better interchangeability and determination of the zero (± 5 μm expected)
- A more suitable mechanical interface



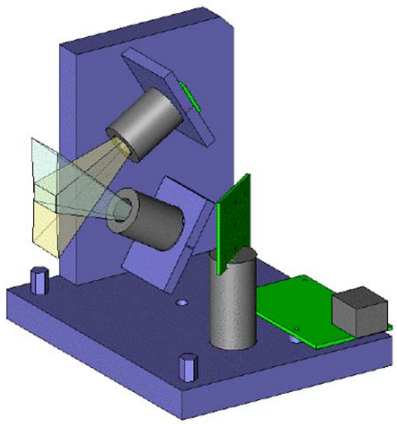


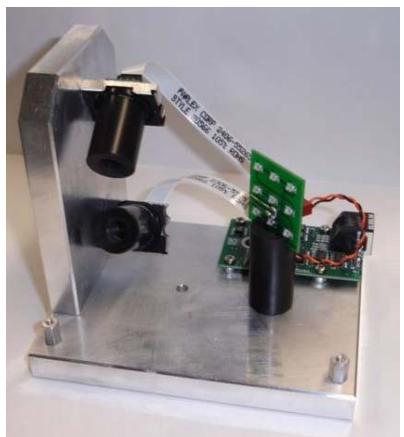
SUITABLE SENSORS

Development of an optical -based WPS sensor



- Promising Vectran wire
- A more suitable mechanical interface
- Absolute measurement within a few microns. (under tests)





PRE-ALIGNMENT STUDY STATUS

- A known and stable alignment reference
- Sub micrometric sensors
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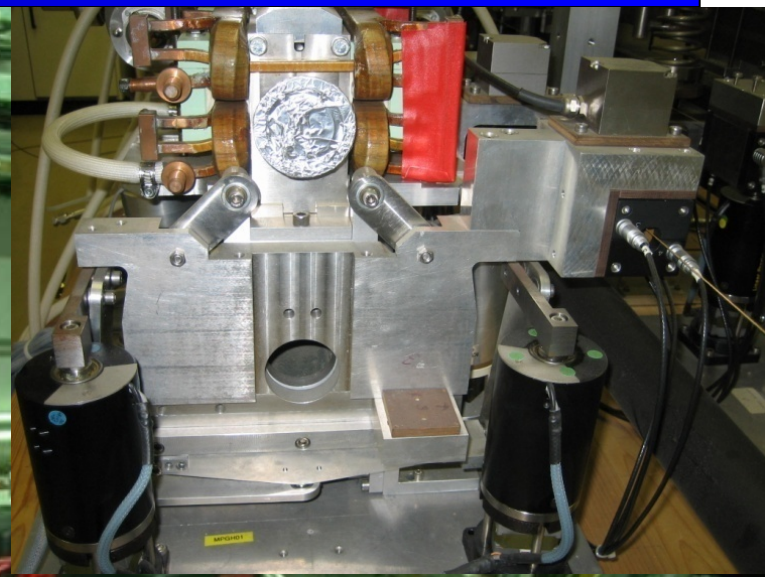
METROLOGY AND FIDUCIALISATION

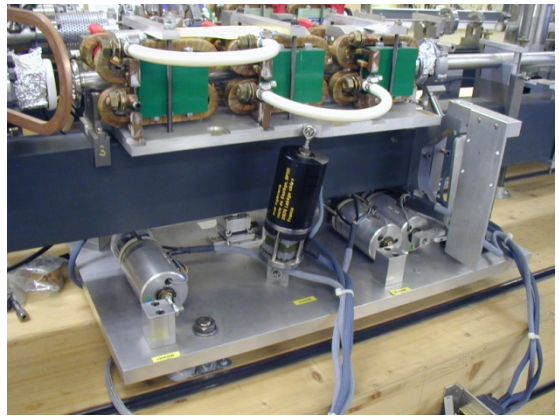
In the CTF2 facility, the components (CAS, PETS) were maintained aligned in a closed loop w.r.t. a stretched wire within a window of ± 5 microns, thanks to sensors and micro movers, in a very radioactive environment.



But…

- Small scale solution to align the accelerating cavities on the girders
- Mechanical design to update (modification of the size of the components, integration of the other equipments and services)
- Fiducialisation within a few microns

METROLOGY AND FIDUCIALISATION



The case of the « main beam » quadrupole

- Aligned independently from the girders along 5 degrees of freedom
- Micrometric supporting solution tested and validated in the CTF2 facility, but non compatible with the stabilization required (1 nm in vertical)

All these solutions will be tested in the CLEX facility (2010-2011), but before it is necessary:

- to propose a solution for the fiducialisation
- to finalize the technical specifications concerning the stepper motors in order to buy the propotypes asap.
- the compatibility between the pre-alignment solution and the stabilization solution concerning the « main beam » quadrupole is studied in conjunction with the Stabilization Working Group.

CONCLUSION

- A R&D strategy is being actively followed.

- CLIC team working full time on the subject:
  - a Surveyor doctorate student, in charge of the methods and strategies of alignment, the simulations, as well as the research studies on the wire itself.
  - a Fellow in charge of the mechanical studies, of the development of an optical WPS, being also an interface with the stabilization studies.
  - a geodesist doctorate student, in charge of the theoretical and practical studies concerning the influence of the gravity on a stretched wire.

- We also would like to open the CLIC survey and alignment studies to the Survey groups from other labs (FNAL, SLAC, Argonne, KEK, DESY), in particular concerning the development and qualification of sensors. The first contacts have already been made.