CLIC prealignment facilities

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Introduction

The CLIC prealignment is a challenge in many ways. The requirement, which is very tight, is one of the CLIC key issue. But in order to fulfill it, several precision limits have to be got over. In this presentation, we are going to present some of them.

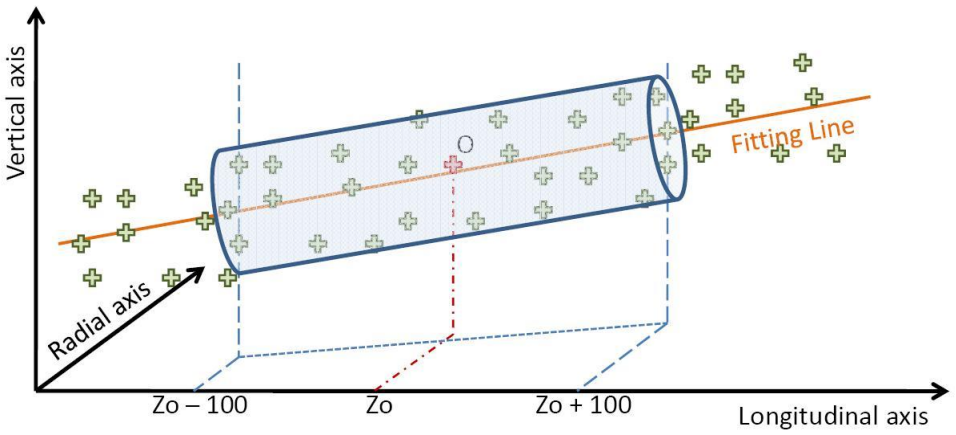
The first one is the accuracy of the sensors. Many micrometric sensors exist. But the micrometric accuracy is much more difficult to reach. For the CLIC alignment, it is essential to have both.

The second limit consists in dealing with the errors propagation. The prealignment must have a precision of a few micrometers along several hundreds of meters.

Prealignment requirements

The CLIC beam size is extremely tiny : 45 nm in transversal and 1 nm in vertical. It involves tight alignment tolerances in order to keep the beam dynamic.

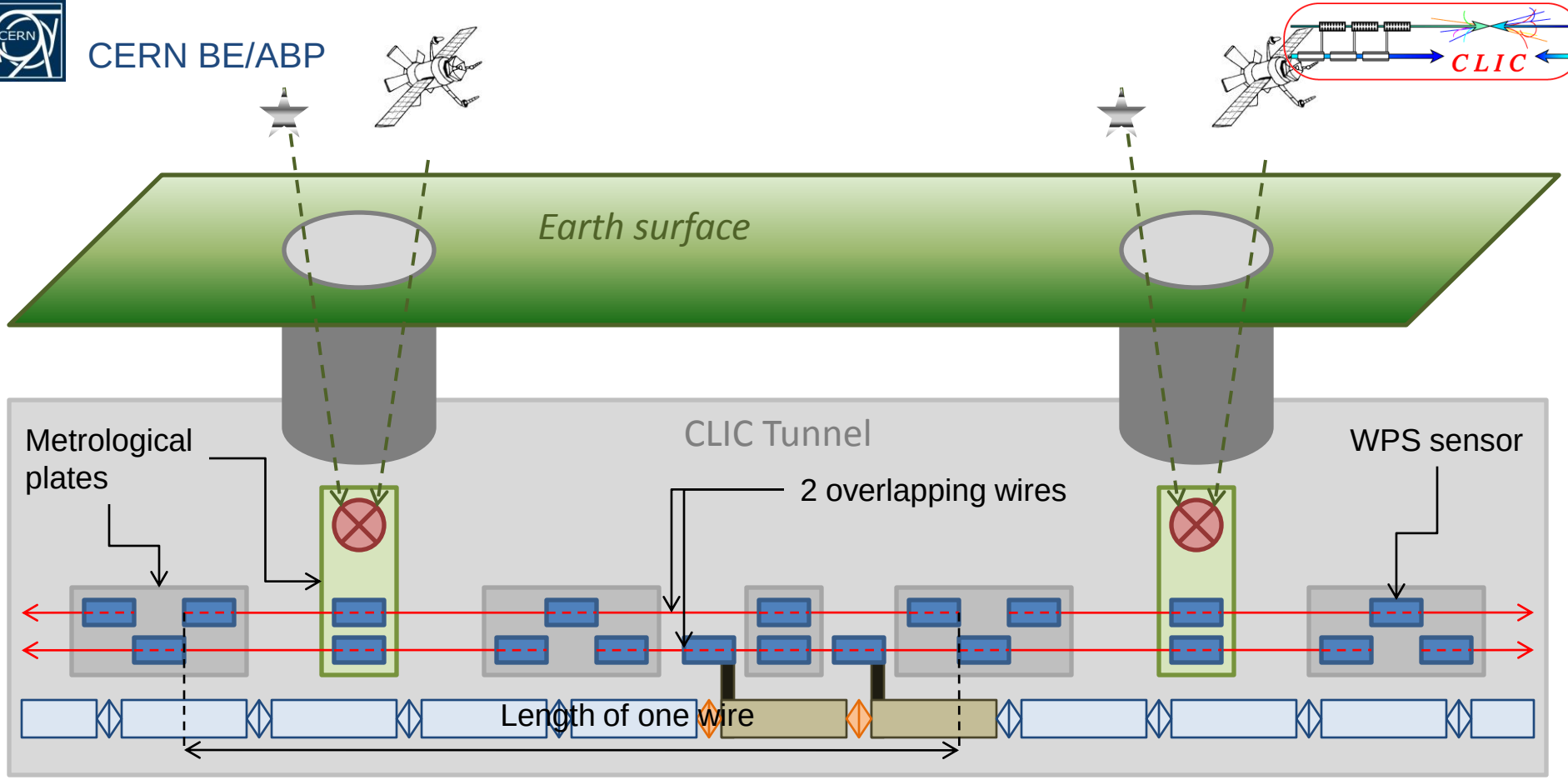
Before the final and beam-based alignment, a pre-alignment has to be made. The tolerances on the transversal and vertical positions are 10 µm along a 200 m sliding window. Both of them are 3σ tolerances…



Along 200 m, the beam entrance and exit points of the CLIC components must form a straight line at 3.3 µm.

It is 100 time smaller than the Earth curvature effect.

The propagation network is supposed to enable this. It is studied to prove if it is feasible or not.



The CLIC prealignment steps :

- A primary metrology network is defined in the tunnel according to the geodetic network on the surface,
- The metrological plates are mechanically pre-aligned,
- The wires are stretched, here is the propagation network…

...with redundancy…

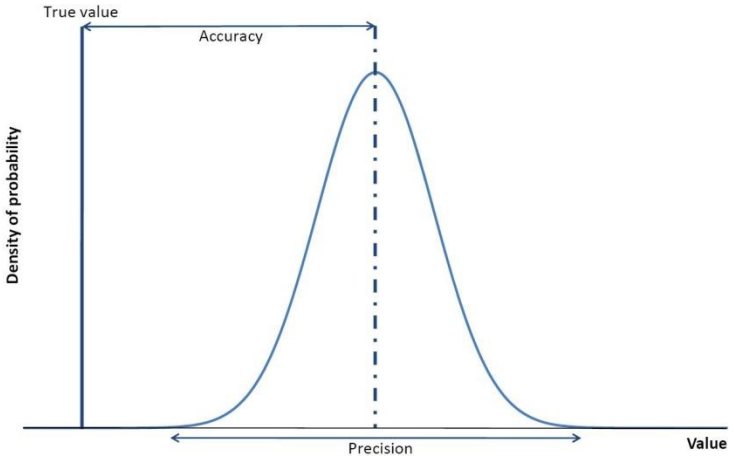
- Girders (supporting the CLIC components) are aligned according to the wire,
- And so on along the whole linac.

Prealignment requirements

Hypothesis of the simulations (1)

Simulations of the CLIC pre-alignment have been made. Let us introduce now the parameters and the hypothesis of these simulations.
The number of pits is not yet defined, nor the lengths of the wires.

The precision of the primary metrology network points is, according to each other, 1 mm + 1 mm per km. The metrological measurements on the plates, in order to go from one sensor to its neigbour, have a 5 µm precision.
The precision on the measurement system wire + WPS is 5 µm. The accuracy of the WPS sensors is 5 µm.

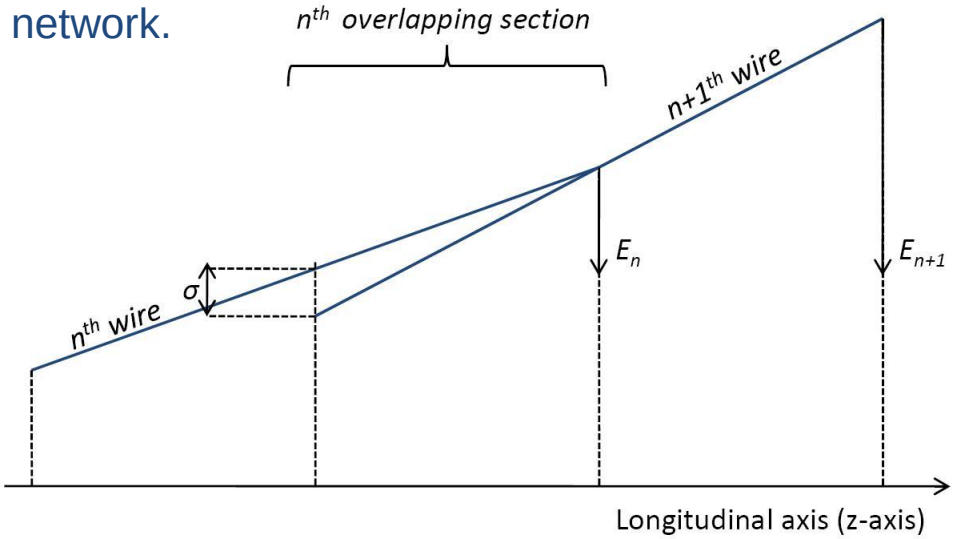


Prealignment requirements

Hypothesis of the simulations (2)

The simulated observations must be as close as possible to the reality. It is not yet the case. For instance the vertical simulations are not significant because LGC does not take into account the ecartometry measurement according to a catenary.

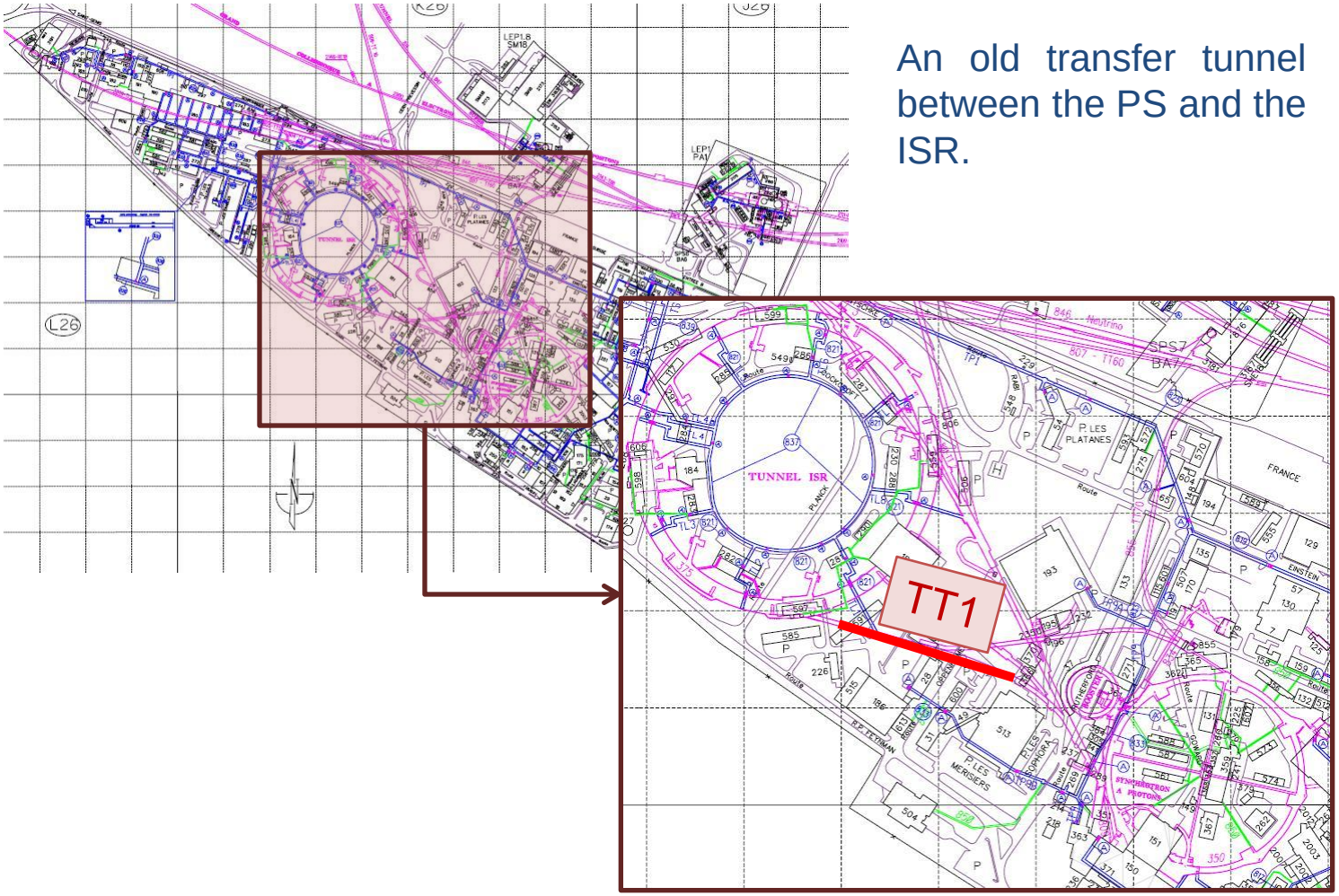
A lot of work remains to improve the simulations. The main one consists in studying the systematic effects or adding redundancy in the propagation network.



$$E_n = n.(n - 1).\sigma / 2$$

Prealignment requirements

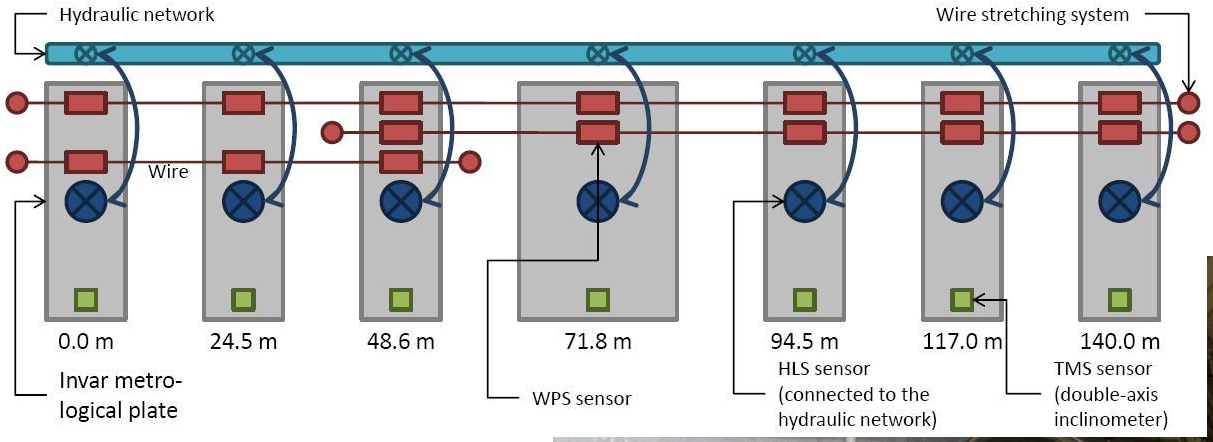
The prealignment facilities – The TT1 (1)



An old transfer tunnel between the PS and the ISR.

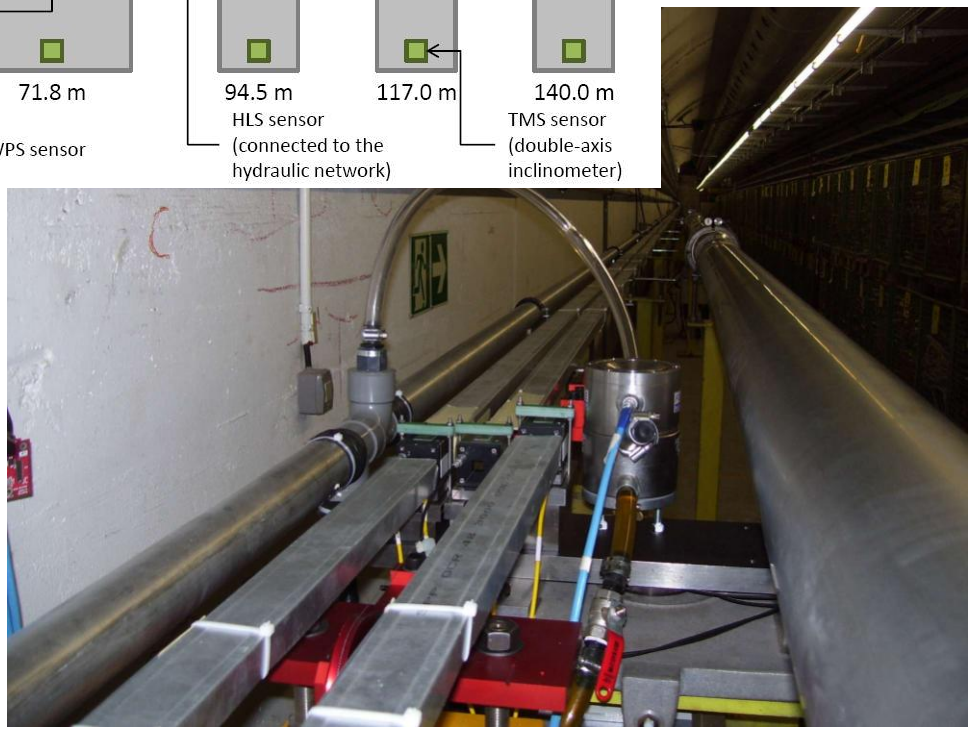
Prealignment requirements

The prealignment facilities – The TT1 (2)



Along 140 m, there are 3 overlapping wires.

The point is the validation of the propagation network by overlapping wires.



Prealignment requirements

Introduction

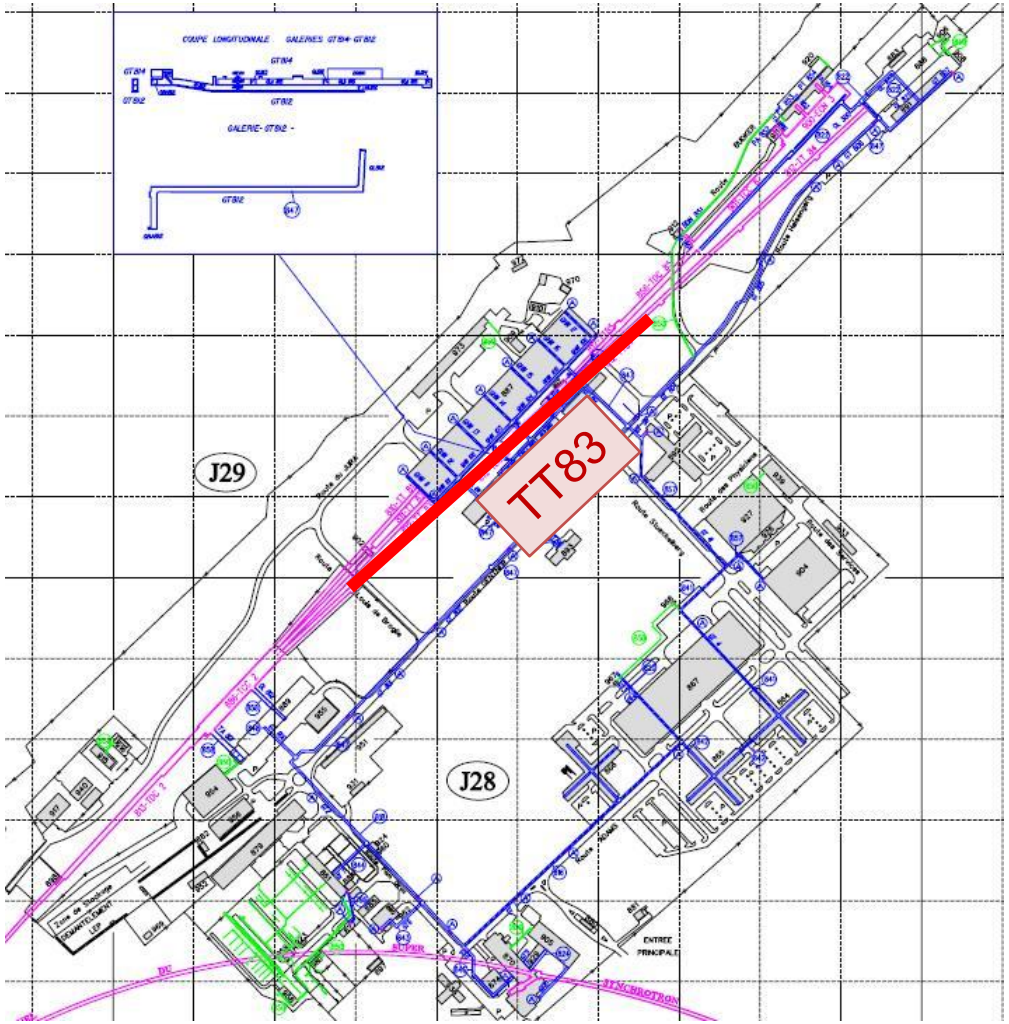
Requirements
- Simulations
- Hypothesis
- ***Facilities***

The wire system

Wire knowledge

Conclusion

The prealignment facilities – The TT83 (1)



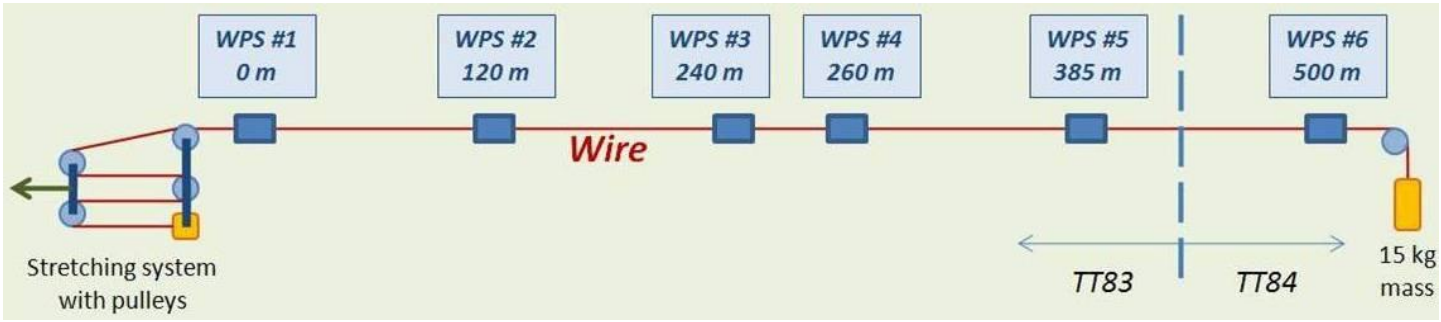
A 500 m wire stretched on the ceiling of the TT83 tunnel.

What is feasible to stretch a wire along such a distance ?

What would be the stability of the wire ?

Prealignment requirements

The prealignment facilities – The TT83 (2)



The stretched wire system

Introduction

Requirements

The wire system
- Resolution
- Precision
- Accuracy

Wire knowledge

Conclusion

The WPS currently used at CERN has a ± 5 mm range. It is producted by Fogale Nanotech, based on capacitive technology.

Its has a 0.1 µm resolution.

Its repeatability is 1 µm.

It might be the truth for a single sensor, alone, with 2 m cables.

What are the resolution, precision and accuracy of our long stretched wires systems ?

The stretched wire system

Introduction

Requirements

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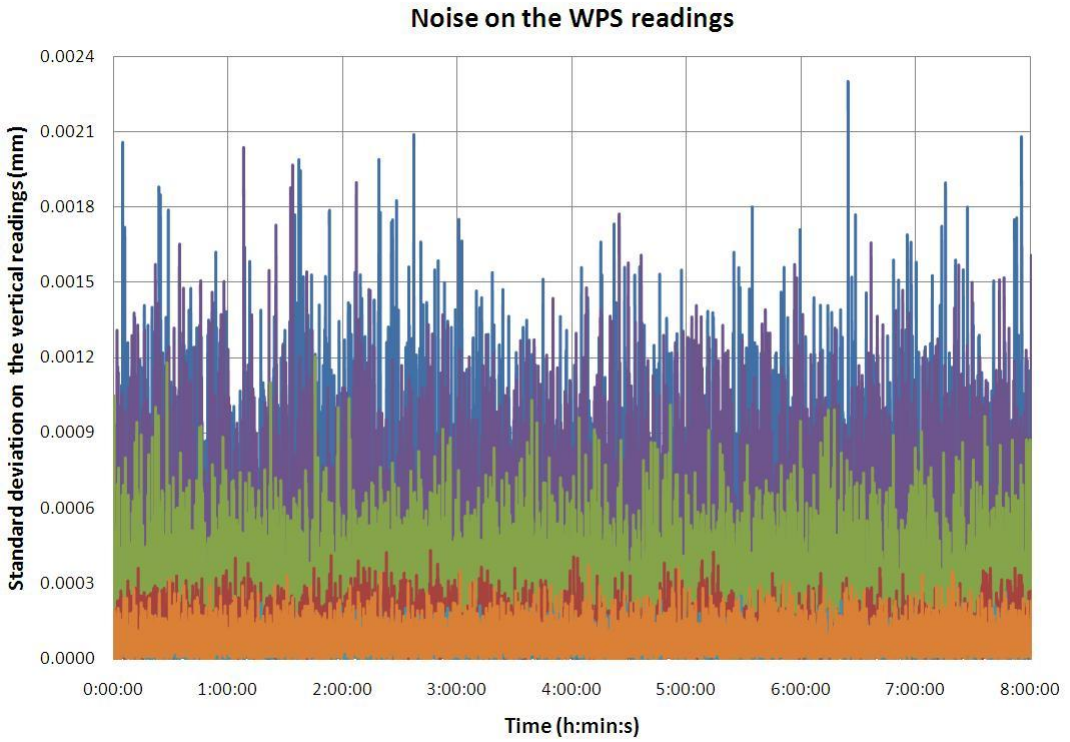
Conclusion

Resolution



RMS values in the TT1.

The RMS values give a clue of the noise in the measurements. Antonio Marin has shown that the resolution in the network depends on the frequencies of the sensors, on the lengths of the cables and on different electrical perturbations. The smallest significant motion depends on this.

The stretched wire system

Precision (1)

Precision is the dispersion of the measurements. It is not that easy to determine. The way chosen here was consisting in the comparison between several measurement systems.

It has been done in the TT1.

A metrological plate has been moved. The motion has been seen by all the sensors, even the RasClic.

The stretched wire system

Introduction

Requirements

The wire system
- Resolution
- ***Precision***
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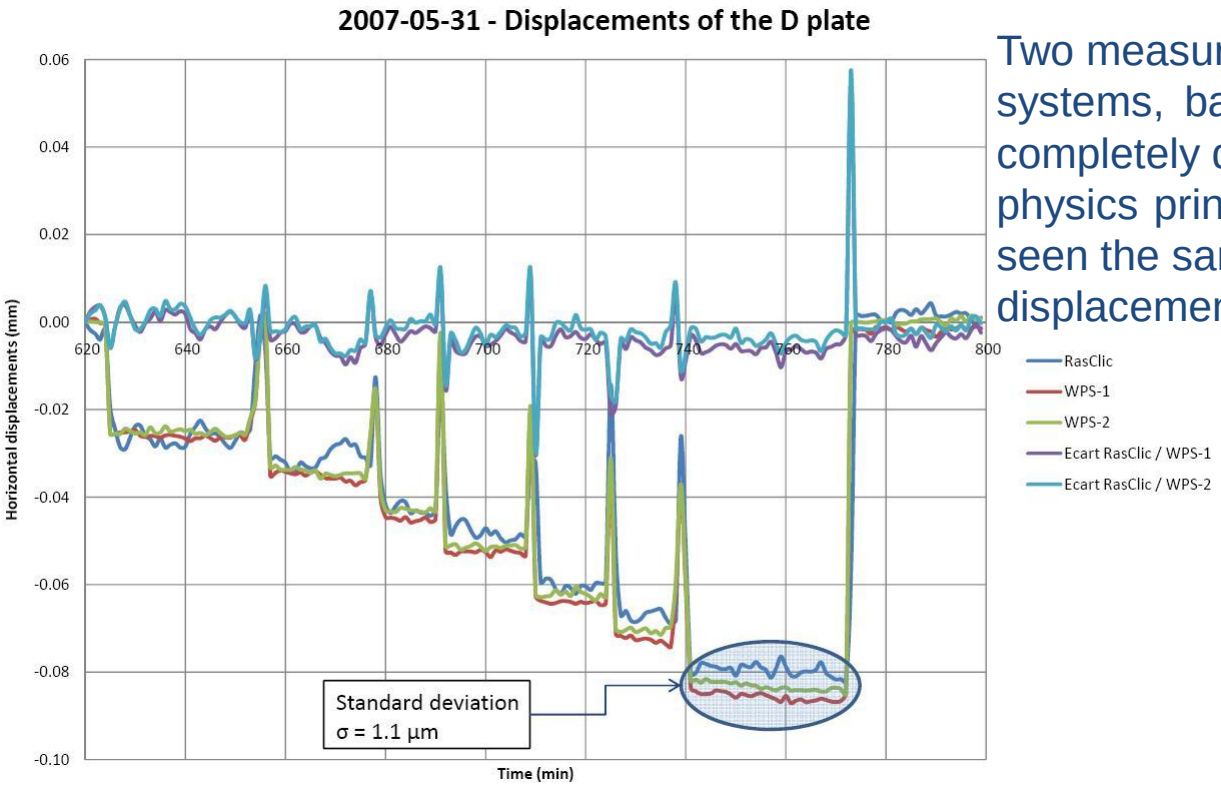
Precision (2)



Two measurement systems, based on two completely different physics principles, have seen the same displacements at 1 µm.

No hysteresis, 1 µm of standard deviation on the differences between the RasClic and both of the WPS !

The stretched wire system

Introduction

Requirements

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- ***Accuracy***

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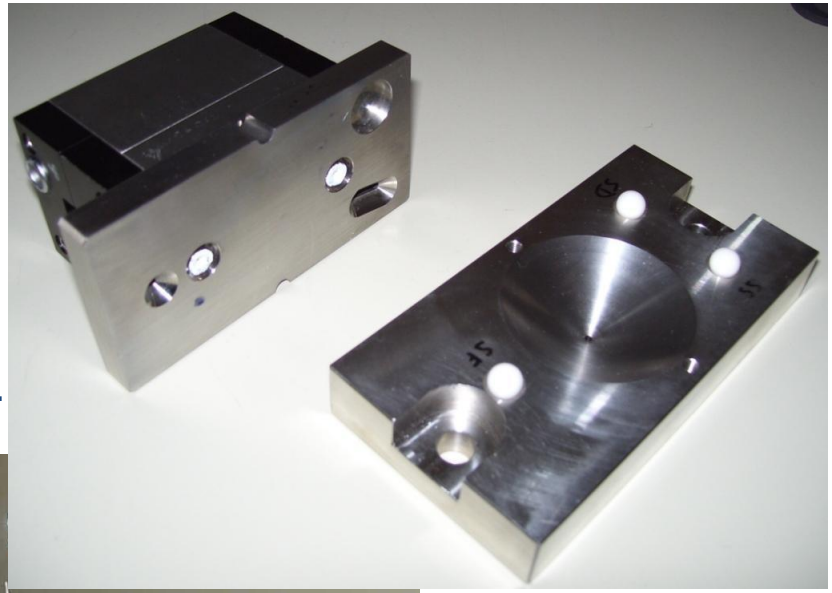
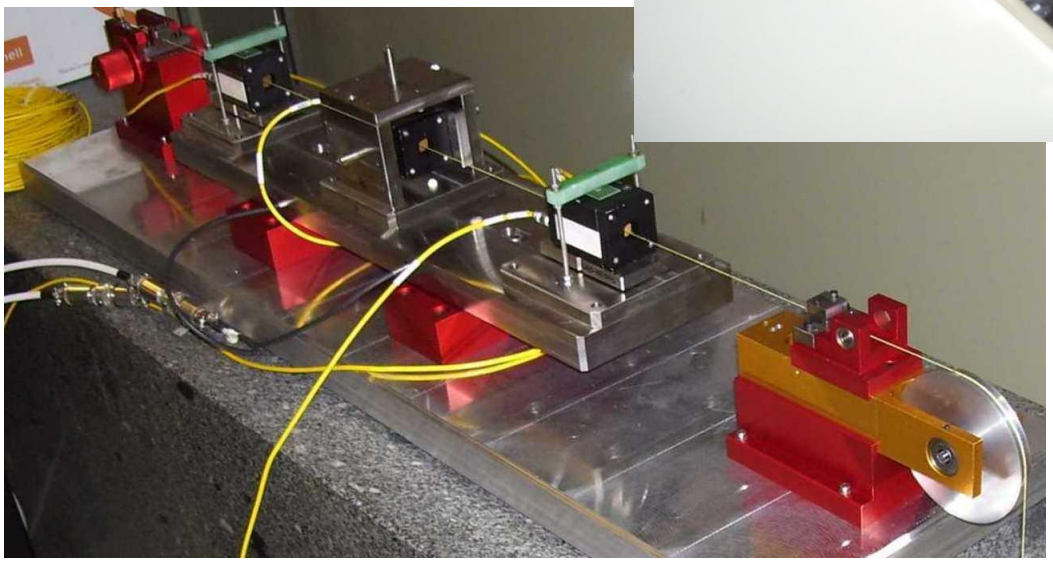
Accuracy (1)

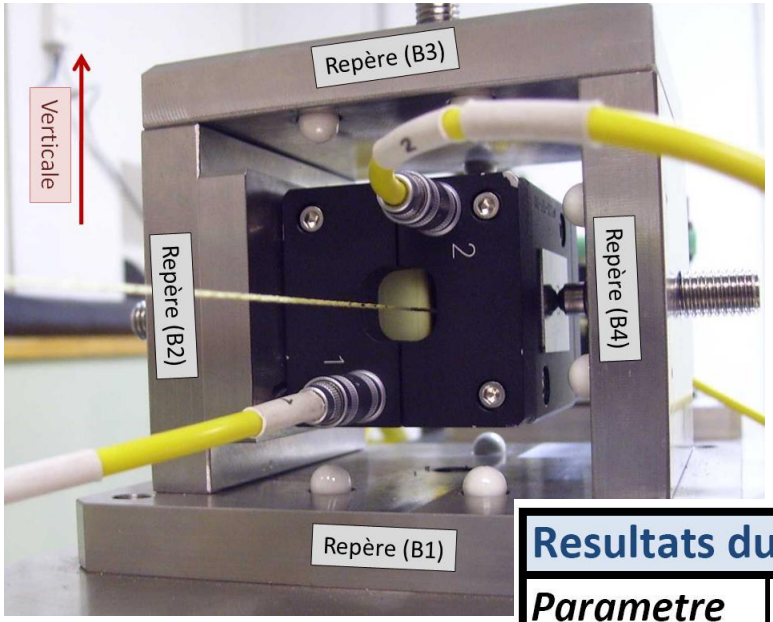
A new interface has been designed, based on three precision balls.
A calibration bench has been built in order to get the rotations and the translations from the center of the sensor to the balls.





The stretched wire system

Accuracy (2)



The parameters are obtained by rotating the sensors around the wire, and centered on known balls.

An accuracy of 5 µm is looked for. Is it feasible compared to the drift of the sensors ?

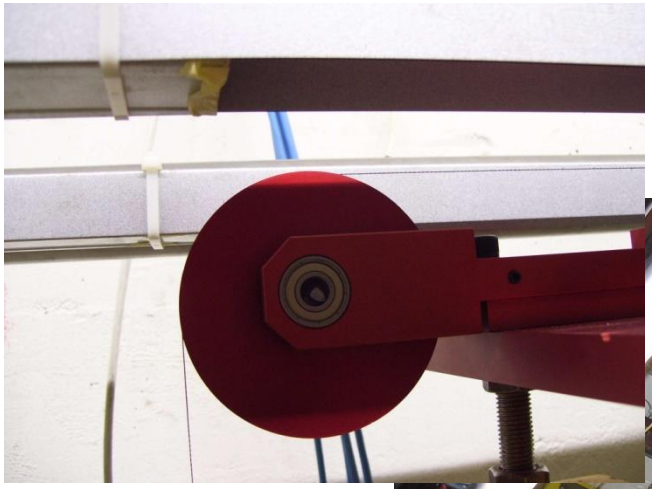
As the bench is designed with the wire in the center, the rotations can't be precisely defined by the least square adjustment method.

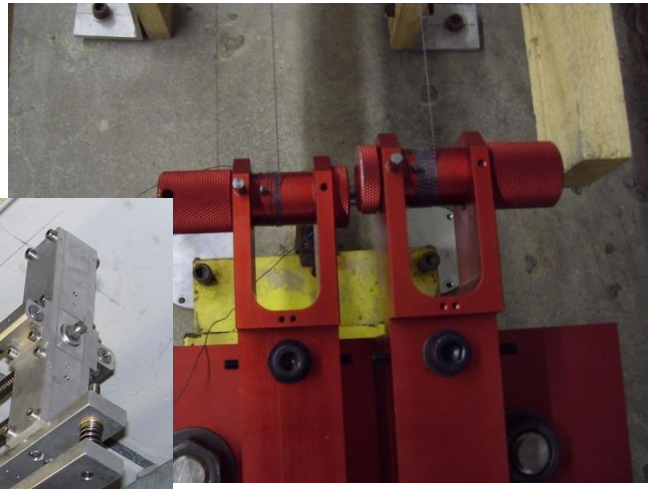
Resultats du 27.01.2009			
Parametre	*Valeur*	*Precision*	*Fiabilite*
τx (mm)	-31.466	2.522	2.573
τy (mm)	-0.522	0.003	0.015
τz (mm)	34.530	0.008	0.021
εx (rad)	8.27E-02	0.016	0.006
εy (rad)	-1.03E-03	0.001	0.011
εz (rad)	-4.98E-04	0.001	0.003

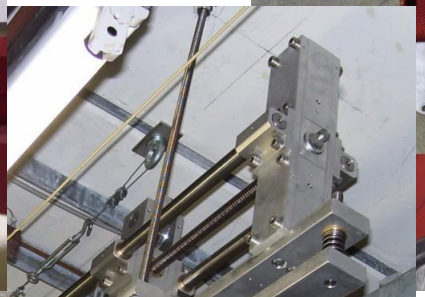
The knowledge of the wire

The wires used for the WPS sensors from Fogale are in carbon-peek. According to the manufacturer, their linear mass is 235 g / km. The tension applied to the wires is usually around 150 N (15 kg).

But wires are not static. They are moving because of different kind of phenomena. Friedrich Lackner has already talked about creep effects. Let us see some others…

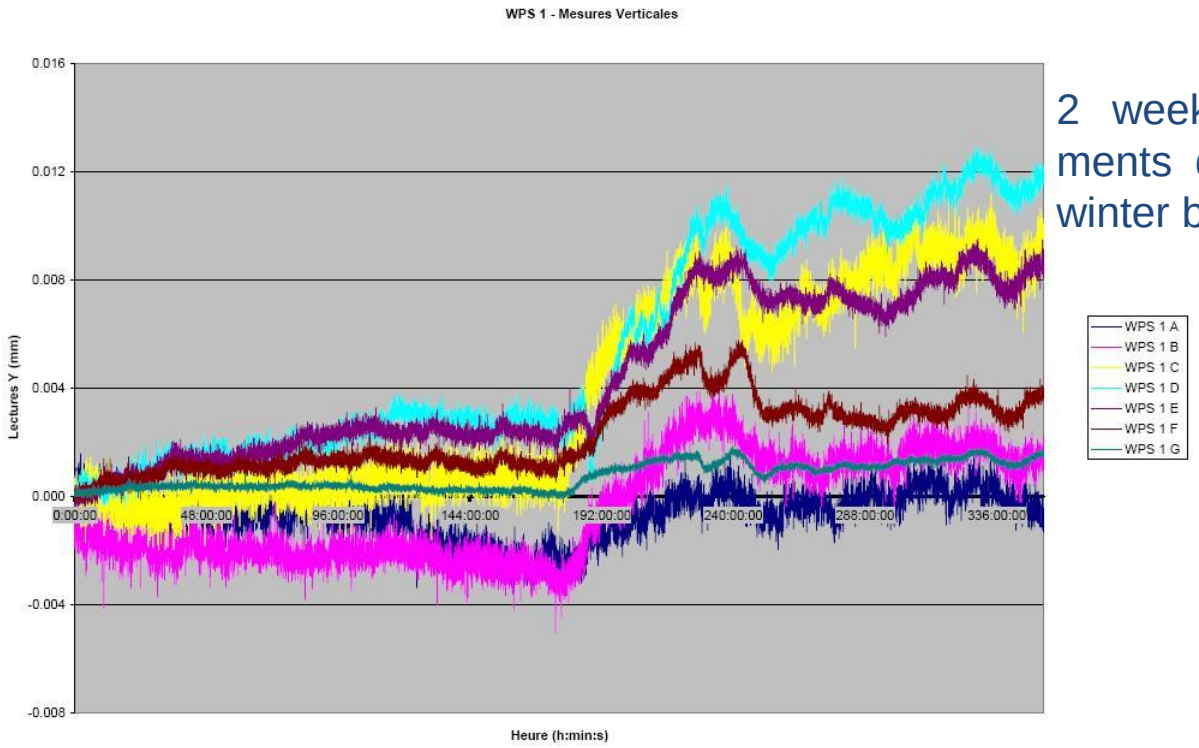






The knowledge of the wire

Long term stability – TT1



2 weeks of measurements during the 2006 winter break in the TT1.

If the meteorological parameters are stable, good measurements can be expected… Unfortunately, perfectly stable meteorological parameters can't be assumed.

The knowledge of the wire

Introduction

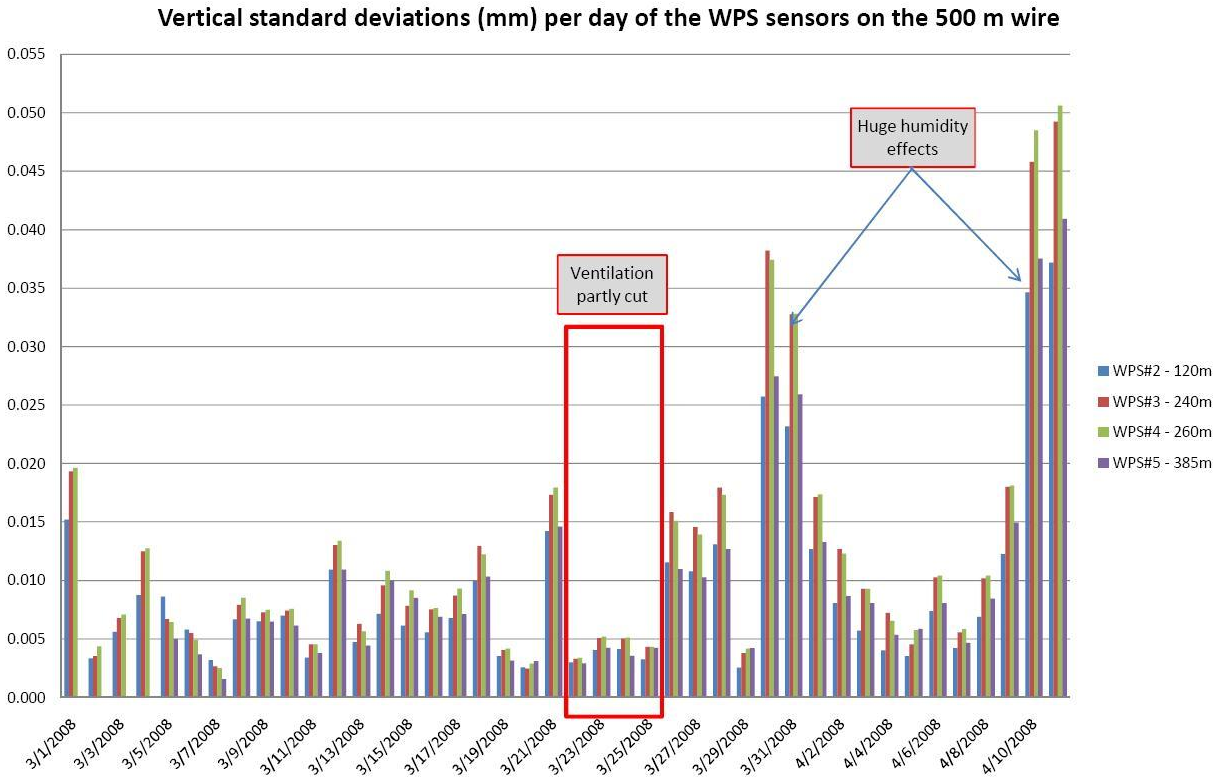
Requirements

The wire system

Wire knowledge
- ***Stability***
- Meteorology
- Forces

Conclusion

Long term stability – TT83



The meteorological effects are not the only ones that can damage the stability of the wire… The ventilation for instance… The wire was stretched immediately near it.

The knowledge of the wire

Introduction

Requirements

The wire system

Wire knowledge
- Stability
- ***Meteorology***
- Forces

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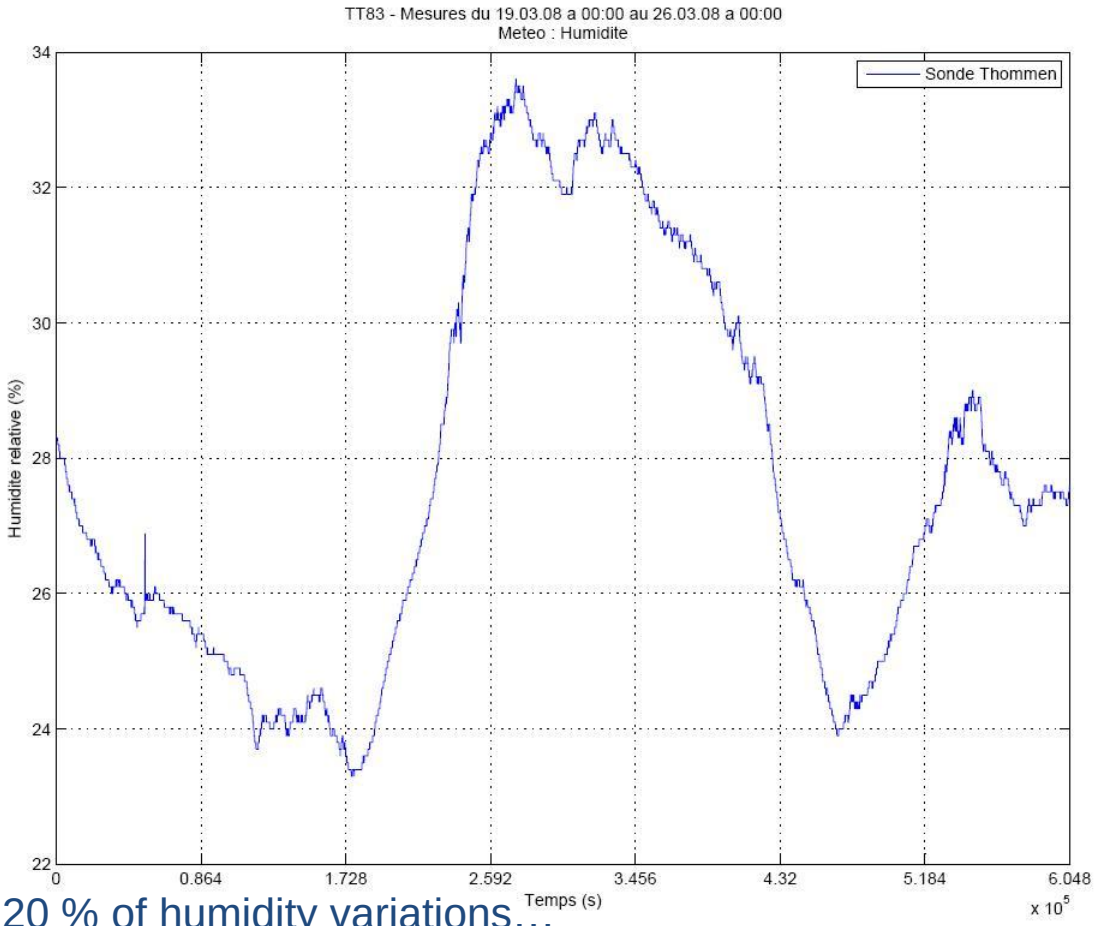
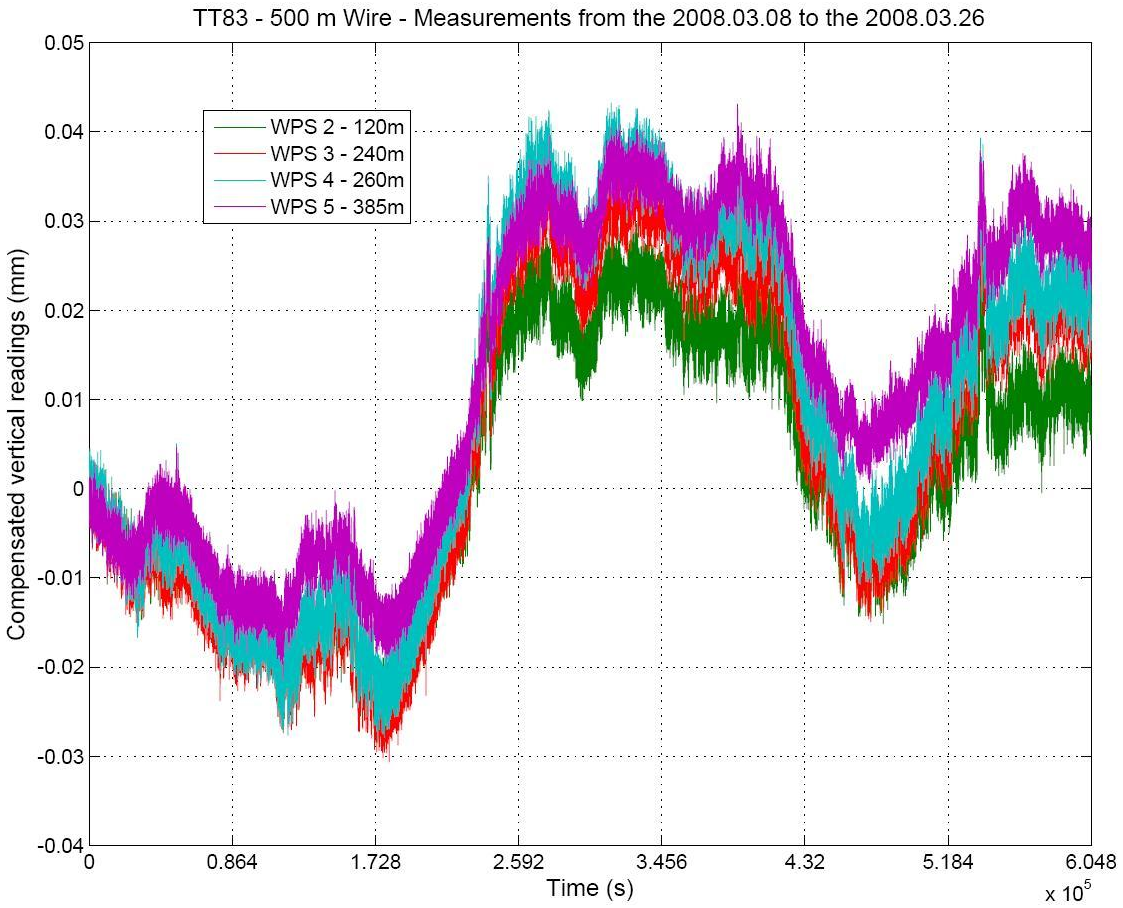
Meteorological parameters in the TT83 (1)



20 % of humidity variations…

The knowledge of the wire

Meteorological parameters in the TT83 (2)

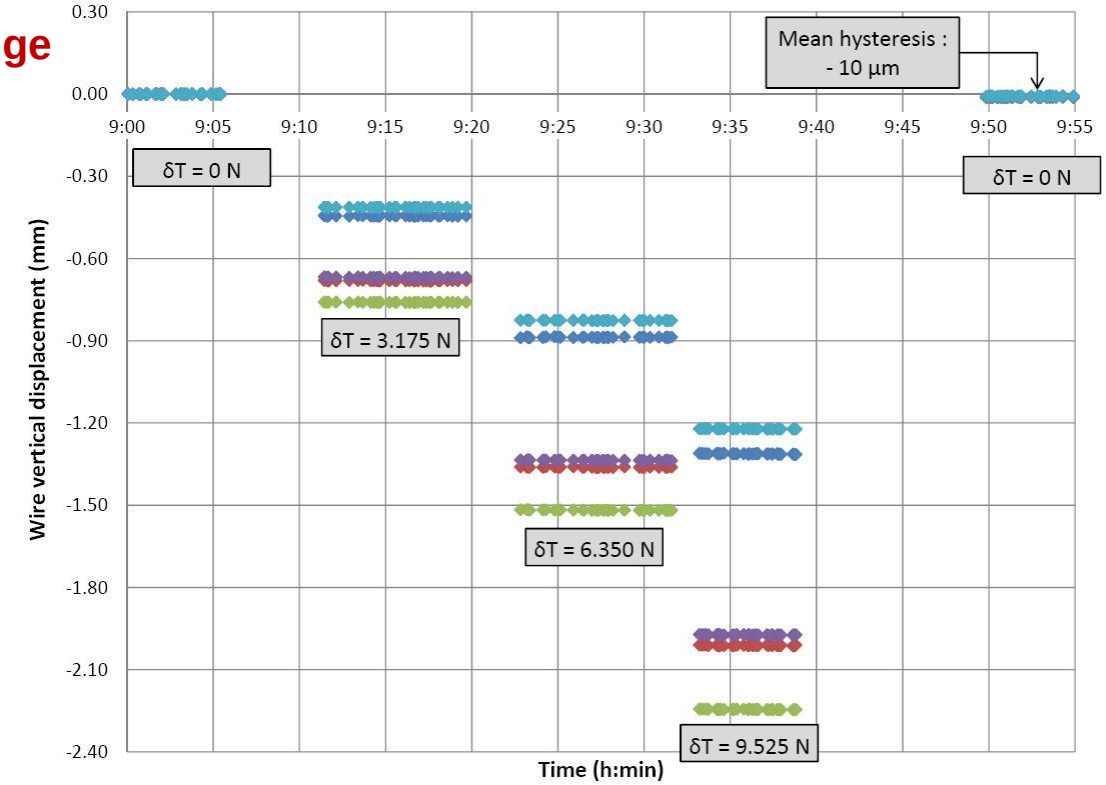


… mean a 70 µm variation of sag (92 % of correlation).

The knowledge of the wire

The forces applied to the wire (1)

The sag of the wire is a function of its linear mass, of its length and of its tension. According to our way to stretch the wire, we can assume the length can't change. But both of the others are not constant.



In the TT1, the tension has been increased in three steps from 146.96N (14.996 kg) to 156.49 N. Then we get back to 146.96 N.

A vertical displacement has been seen by all the sensors.

The knowledge of the wire

Introduction

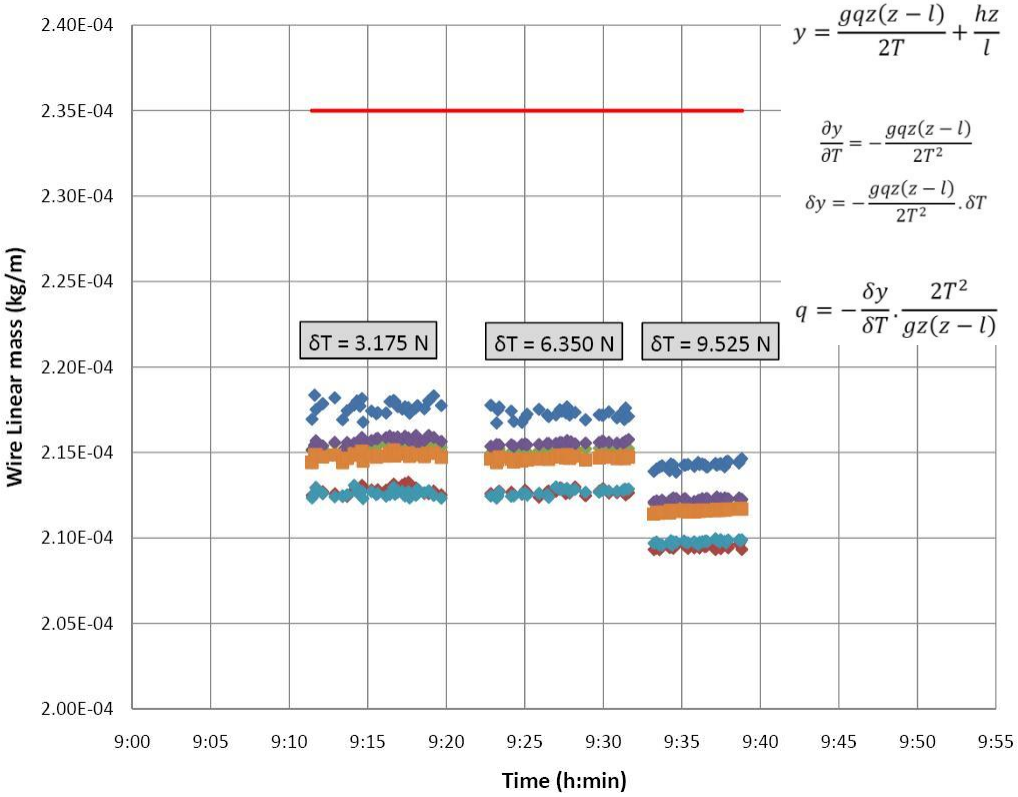
Requirements

The wire system

Wire knowledge
- Stability
- Meteorology
- ***Forces***

Conclusion

The forces applied to the wire (2)



Knowing the displacements and the tension variations, the linear mass can be computed from the datas.

It is different to the theorical value (20 g / km) and is varying.

Something else but the tension of the wire has changed. It could be probably understood by monitoring the elongation and the tension of the wire on each facility.

Conclusion

Thanks to the different studies, tests and facilities made previously, we have a good idea of the resolution, stability and precision of long stretched wires systems.

The next step is the determination of the offsets of the WPS sensors. The aim is to reach 5 µm of absolute accuracy. As soon as we get them, it will be implemented in the TT1 to study the overlap of the wires.

These studies in parallel with the simulations should validate the feasibility of the CLIC prealignment.

Thanks for your attention !!!