Alignment methods developed for the validation of the thermal and mechanical behavior of the Two Beam Test Modules for the CLIC project

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IWAA2014
October 13-17, 2014
IHEP, Beijing, China

Agenda

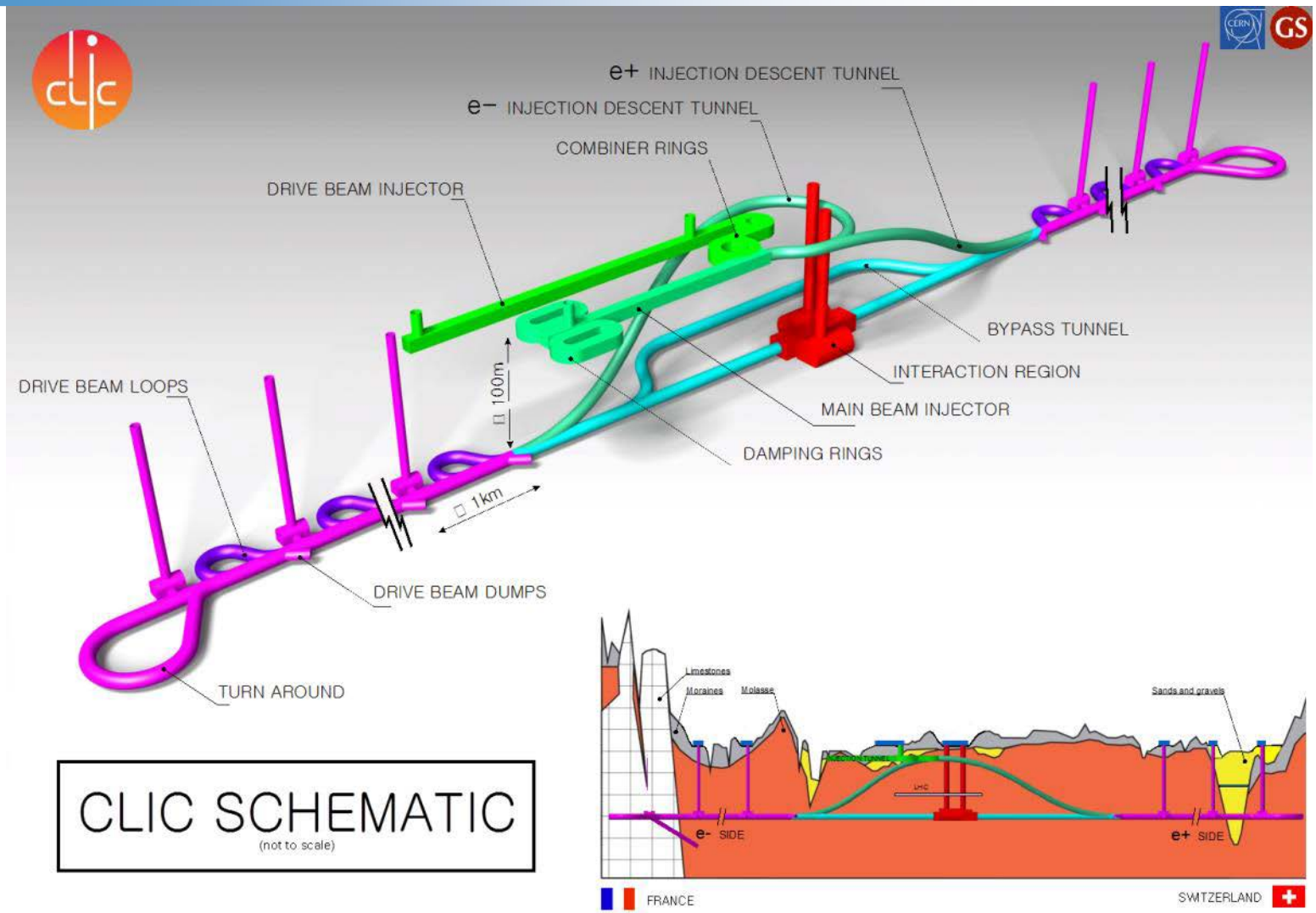
Thermal & mechanical behavior of TBTM: alignment methods developed & misalignments observed

Outline

- Introduction
- Short range strategy of pre-alignment on module components
- Preparation of the thermo-mechanical tests
- Methods of measurements developed
- Results obtained

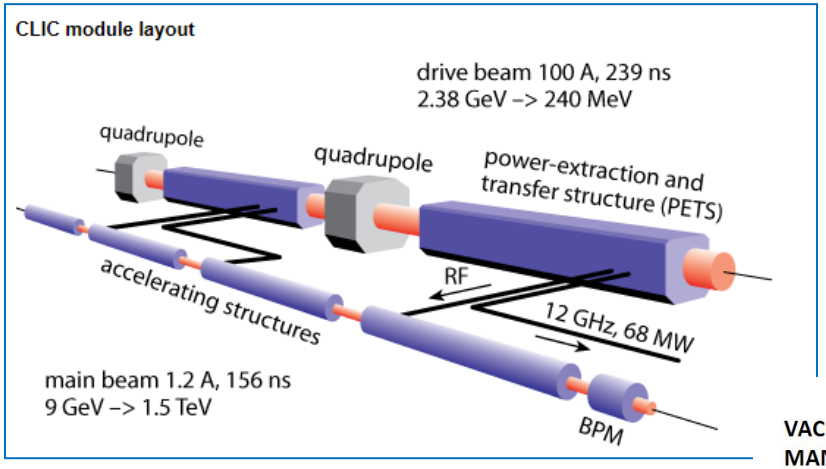
Introduction

CLIC project

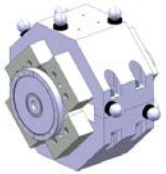


Introduction

CLIC module

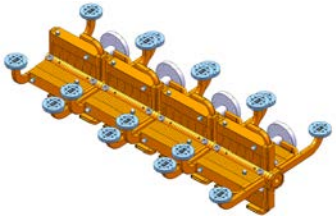


Components:



Quadrupole

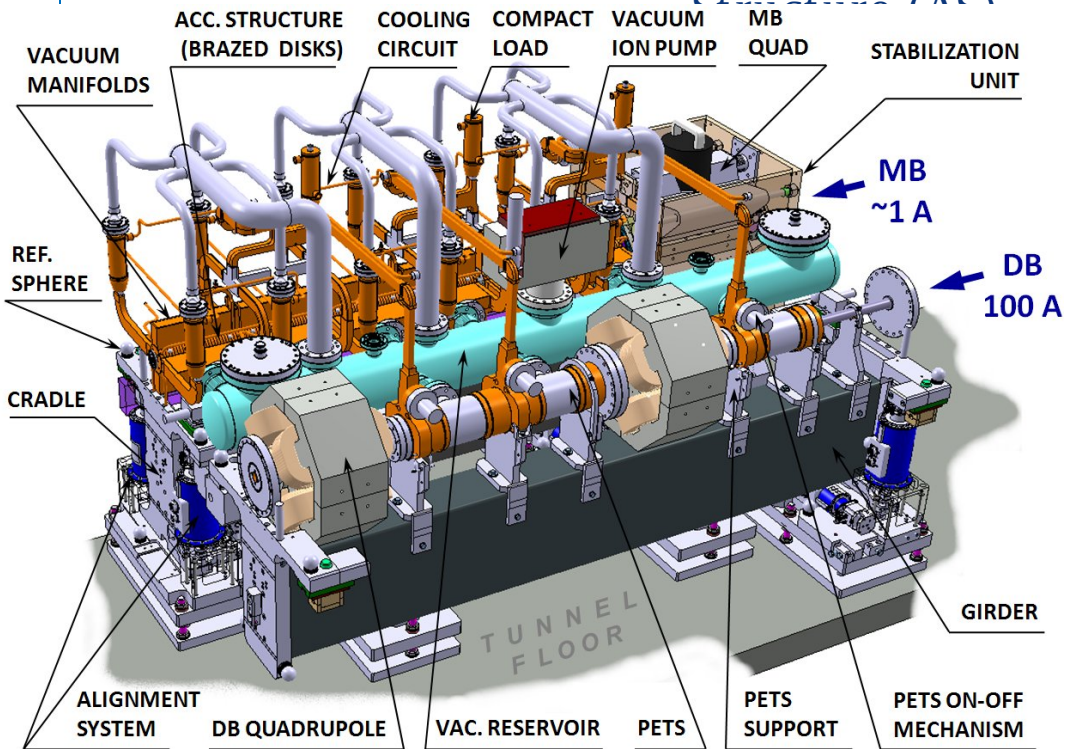
PETS



Accelerating Structure (AS)

Modules = key component of CLIC

- Length = 2 m
- 20 000 modules



Introduction

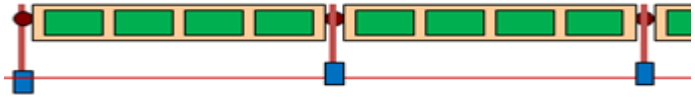
CLIC module

- Validation of the assembly & integration of the components
- Validation of the short range strategy of pre-alignment
- **A better understanding of thermal and mechanical behavior of a module under different operating modes** ⟵ Misalignments observed

Short range strategy of pre-alignment

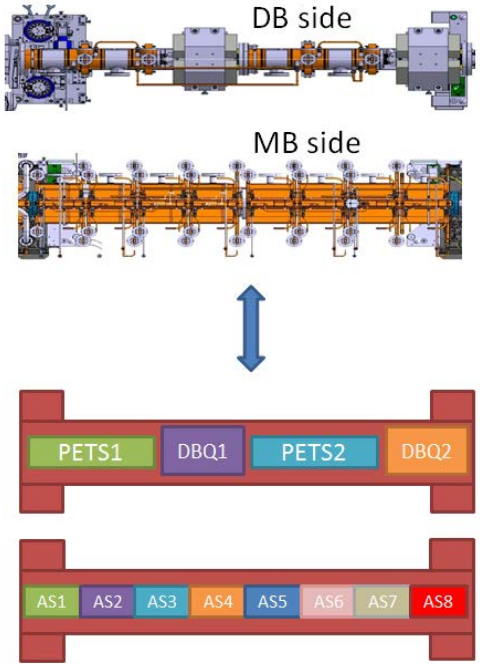
Strategy

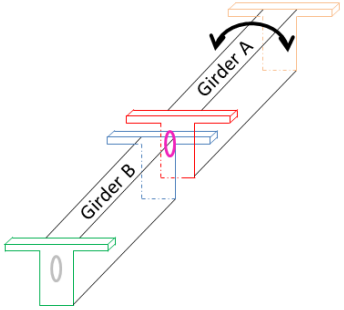
Pre-alignment of several components on 1 support

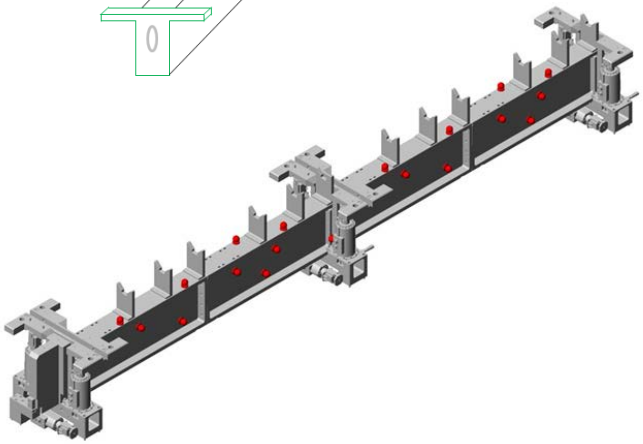


2 cradles per girders "snake configuration"

cWPS & actuators coupled to

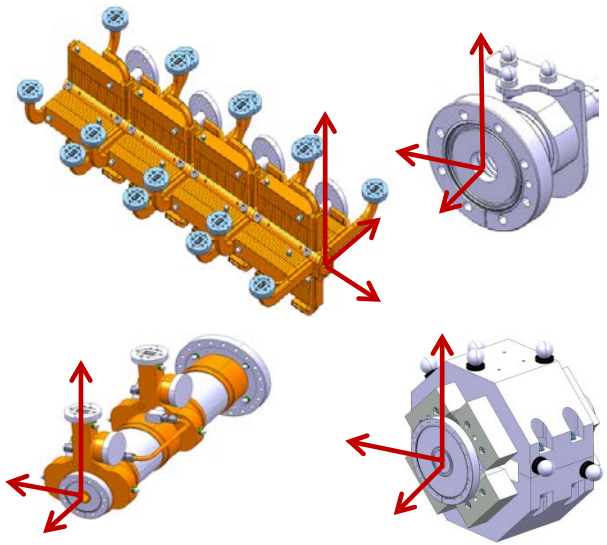




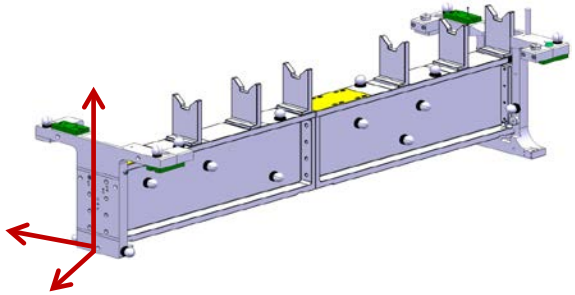


Short range strategy of pre-alignment

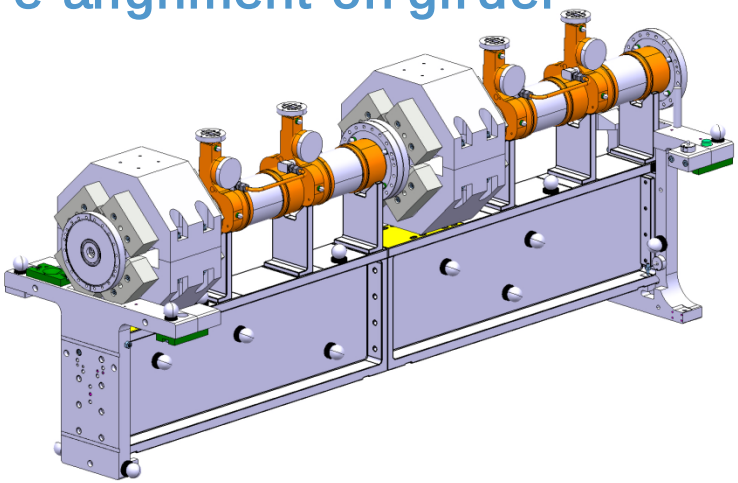
Process of pre-alignment



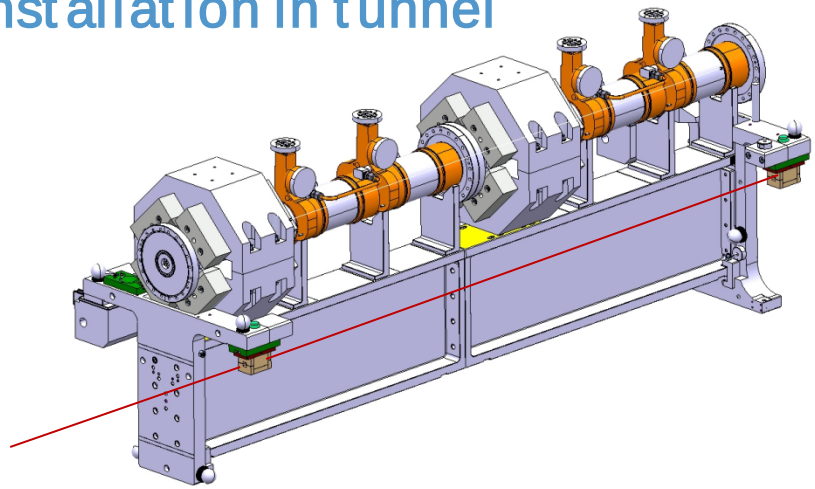
Fiducialisation



Pre-alignment on girder



Installation in tunnel



Preparation of thermo-mechanical tests

Context of measurements

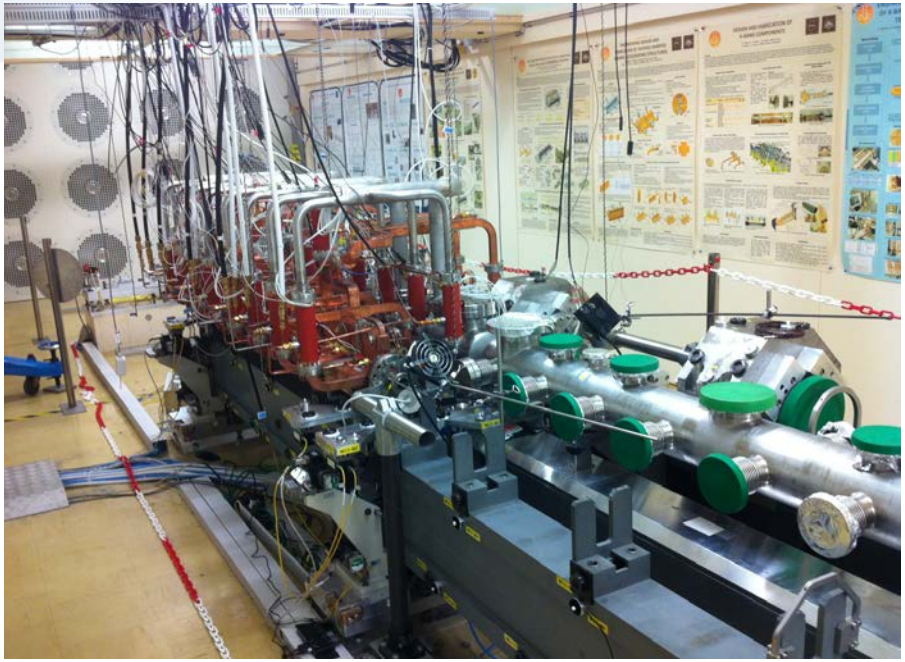
Tunnel environment reproduced by air conditioning & ventilation system:

- T°C from 20 °C to 40 °C
- Longitudinal air speed: 0.3 to 0.8m/s

All components equipped with electric heaters to reproduce the power dissipation estimated in the module

Cooling system integrated in RF components (not in the DB quadrupole)

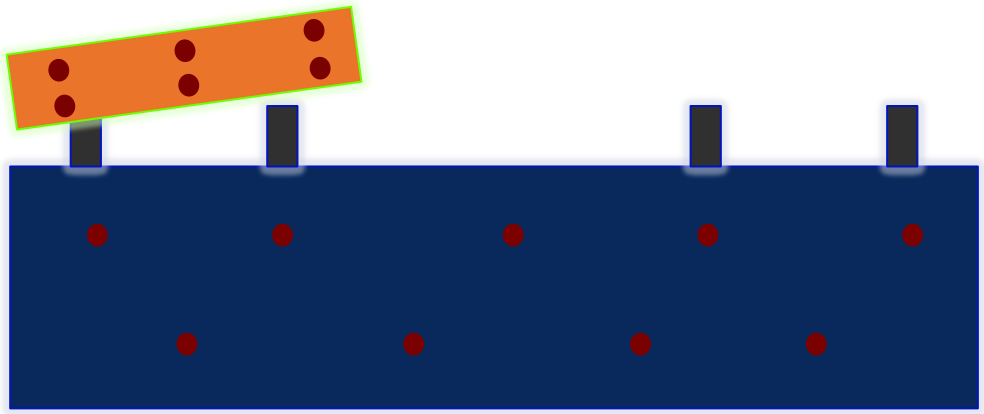
Finite Element Analysis prepared with ANSYS to simulate displacements (but ready during the measurements process)



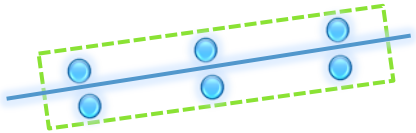
1st operating scenario simulated:

- Zero position
- Power-up of DB quadrupole
- Unloaded conditions (RF but no beam)
- Loaded conditions (RF + beam)

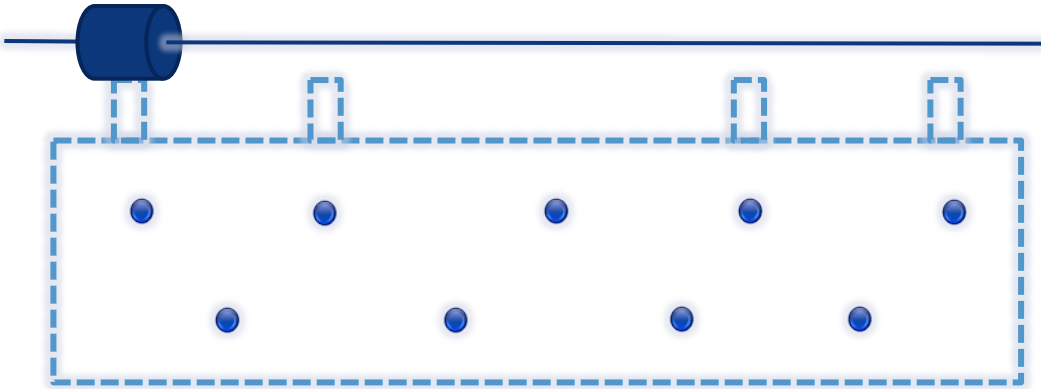
Preparation of thermo-mechanical tests



Measurements using the laser tracker AT 401



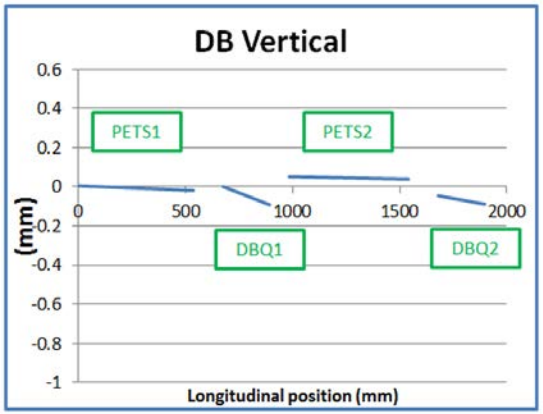
Position of the fiducials w.r.t mechanical axis of the component

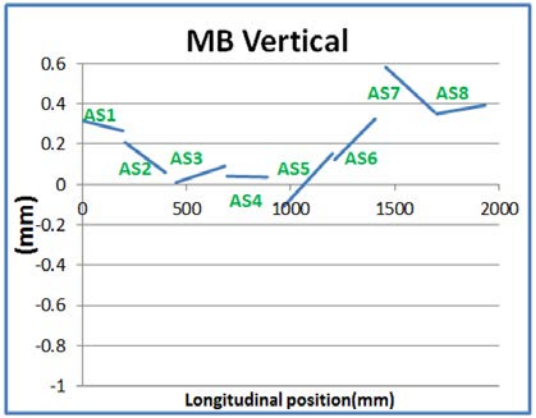


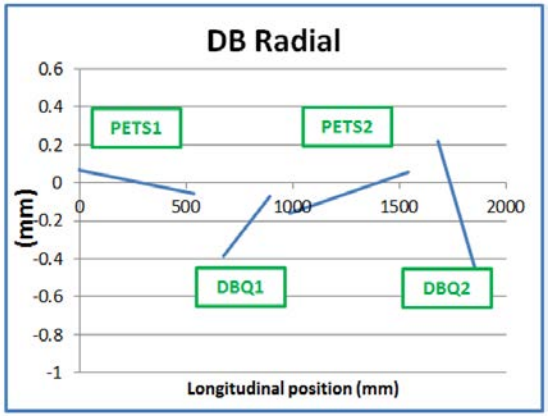
Position of the fiducials w.r.t V-shaped support axis

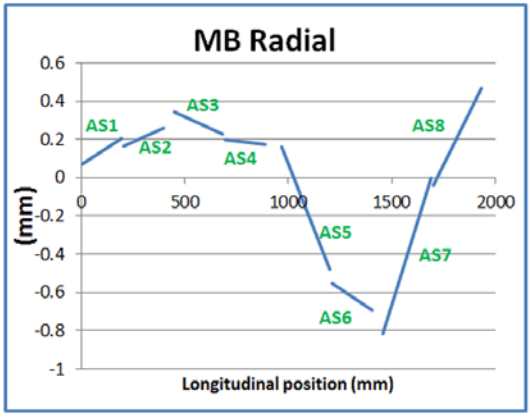
Preparation of thermo-mechanical tests

Zero position of the components







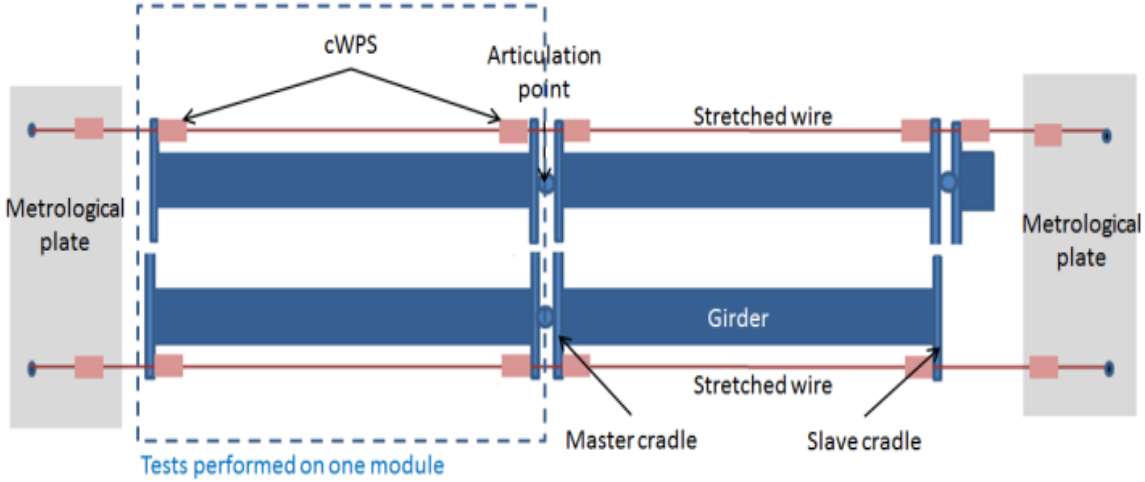


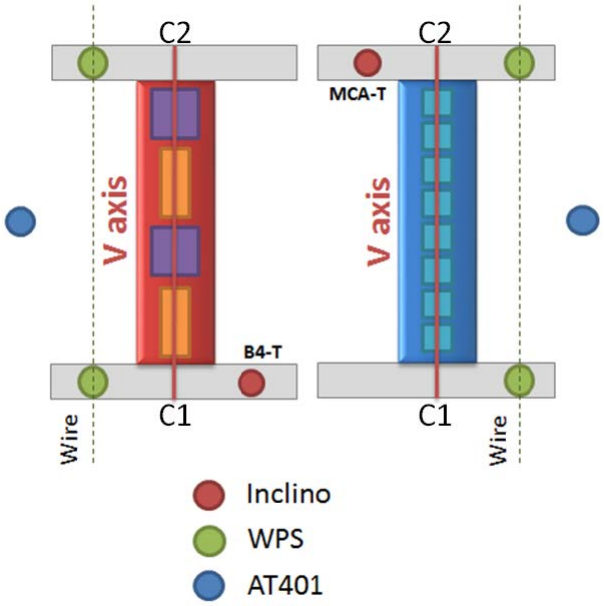
Methods of measurements

Means of measurements

cWPS coupled to the cradle → Permanent monitoring of the position of the girder (mean axis of V-shaped support), within a few µm

AT 401 measurements → Position of the components on the girder





Methods of measurements

Means of measurements

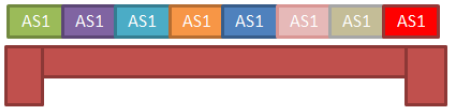
AT 401 measurements

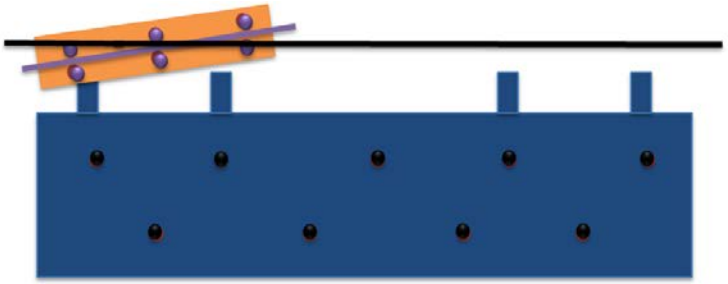
- Nobody allowed in the room during the measurements
- Use of a heavy tripod for a better stability
- Duration of a station < 45’
- Warm-up of AT401 4 hours before the first measurements
- All measurements performed back side and front side, integrated over 5’’.
- Fiducials located on the girder considered as references during best-fits (as measured by CMM)

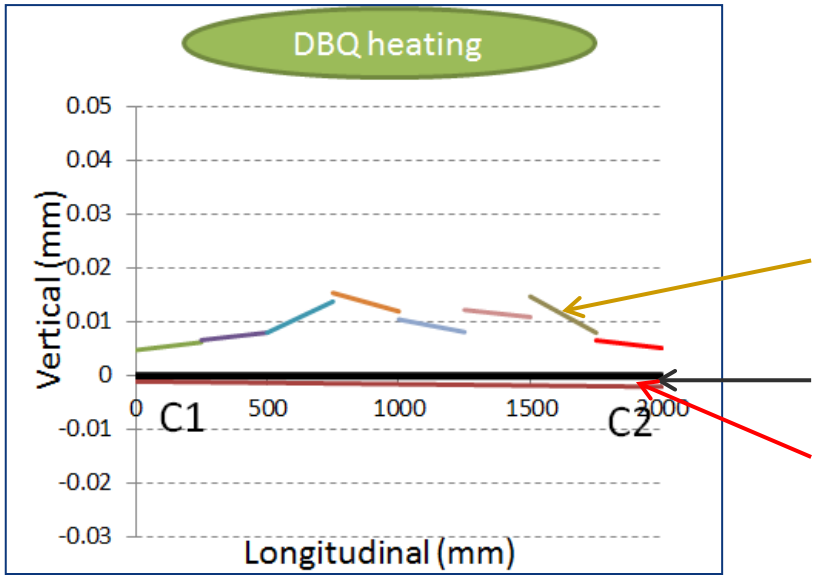
Results : misalignments observed

Misalignments of components

How to understand the data?







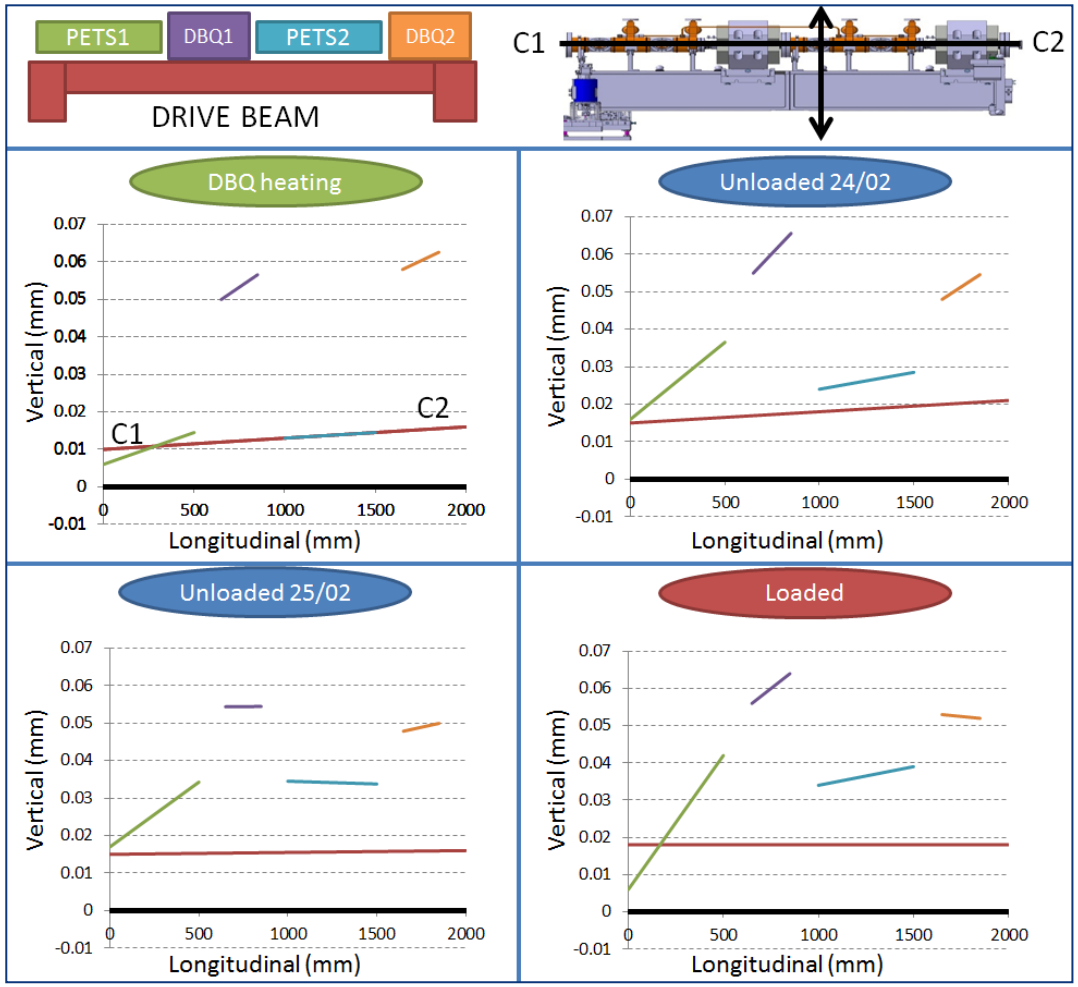
current position of the mean axis of component w.r.t mean axis of girder

initial position of the mean axis of girder

current position of the mean axis of girder

Results : misalignments observed

Misalignments of components

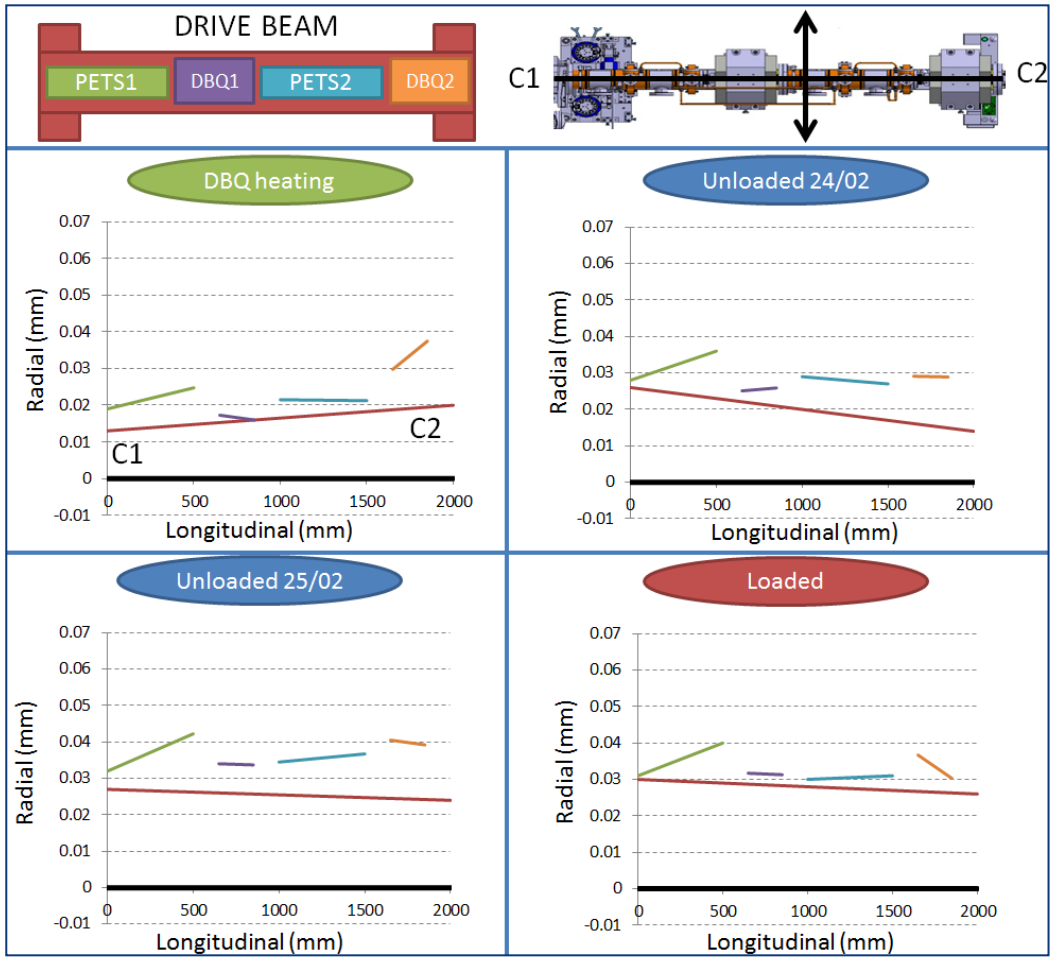


During the DBQ heating: vertical displacements of ~40µm are observed, as no cooling system is associated with the DBQ (for a T°of 35 °C)

The unloaded cycle has been performed twice: this gives a good idea of the repeatability, better than 10 µm and confirms the precision of measurements

Results : misalignments observed

Misalignments of components

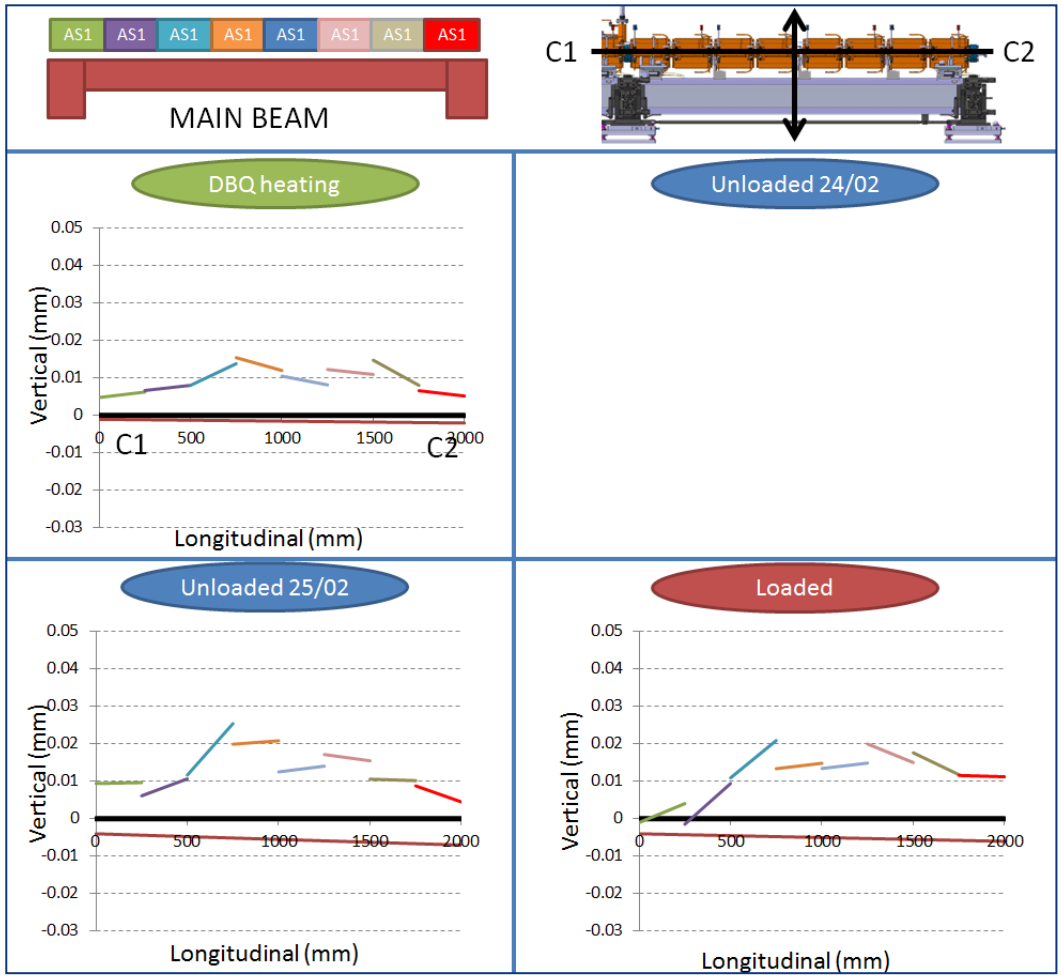


No radial displacements visible, which seems logical: a T© increase should not misalign radially the reference axis of the component as it is symmetric.

Very good repeatability: this confirms the precision of measurements

Results : misalignments observed

Misalignments of components

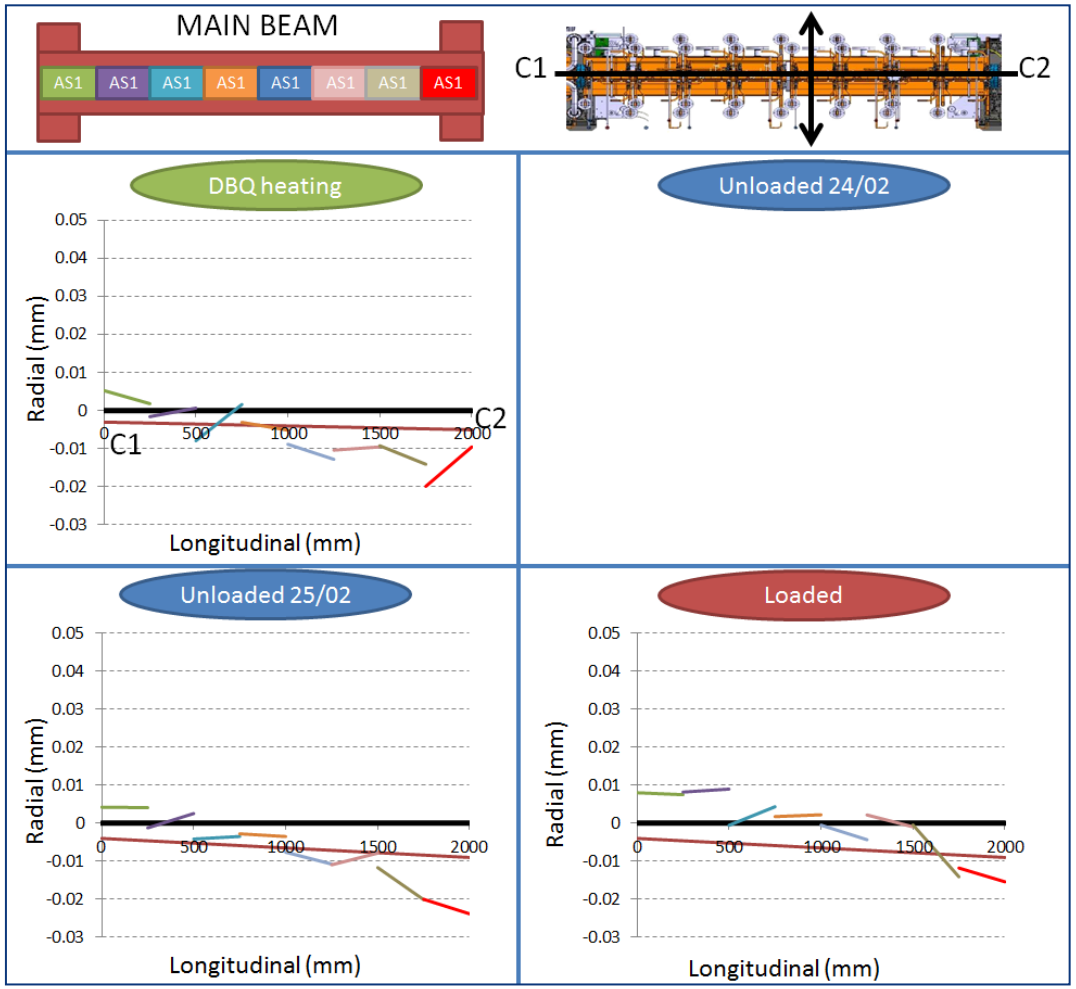


Misalignments during the first phase are very small, which is logical as there is no heating on the MB side.

The cooling system plays its role during the unloaded and loaded phases: misalignments < 20 µm

Results : misalignments observed

Misalignments of components



No radial misalignments observed as the component is symmetric.

Summary

One first duty cycle (machine start-up) simulated

- Heaters added to the components, cooling system to RF components
- T© cWPS, AT401 measurements performed
- FEM carried out

- Very small impact of such cycle on the alignment of components that are cooled down
- Good matching between simulations and measurements
- At the limit of the uncertainty of measurements of AT401

Improvement of the methods of measurements needed

- Have a better knowledge of thermal expansion of the cradle (where sensors are located) w.r.t girder
- Increase the number of stations per side
- Use simultaneously 4 AT 401 measuring the position of the components
- To equip all the components with fiducials
- To automatize the process of measurements

Would anybody have an experience in that?