



# **Specific Case : Crab-cavities**

*Alignment review 2019*

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# Context

- **Assembly measurements of the DQW prototype**
  - Measurement on the associated infrastructures
  - Workflow (Assembly of the Crab-cavities)
  - Installation of FSI system
  - Validation at warm and cold conditions
  - Installation of the DQW prototype in SPS tunnel
- **Extrapolate to the next Crab-cavities**
  - Extrapolate to the RFD prototype
  - Extrapolate to the 10 Crab-cavities assembled through in kind contribution (from UK and Canada)

## Objective of this presentation:

To give you an idea review of the different steps activities for the assembly measurements of the DQW prototype.

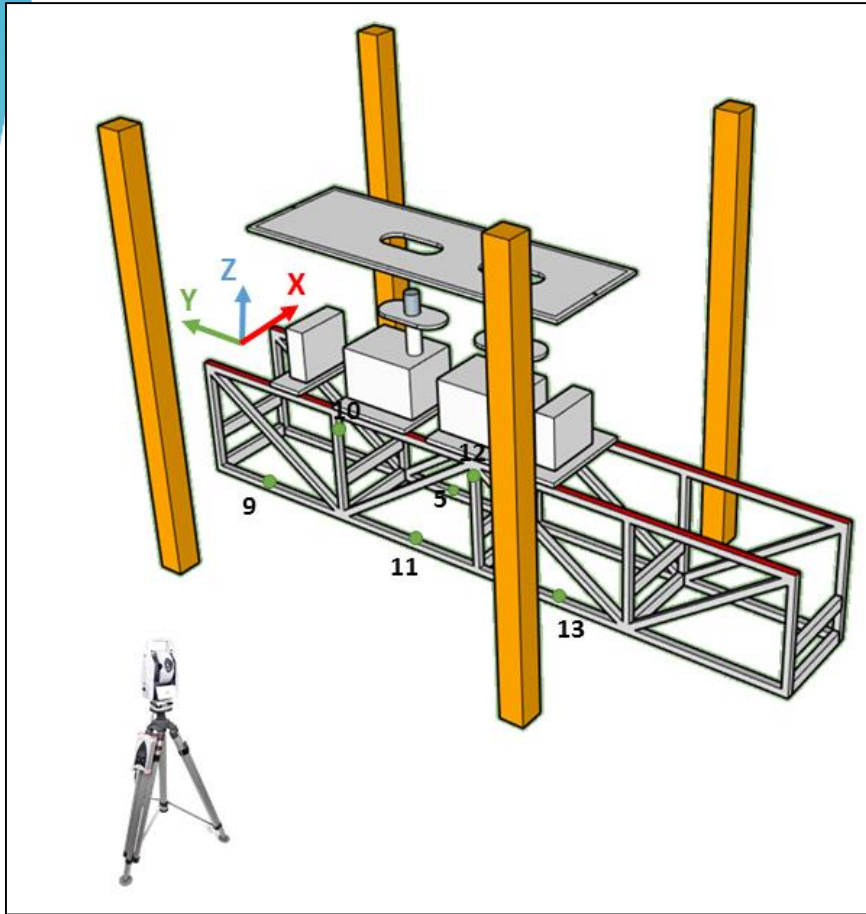
→ *Review of the activities linked with crab-cavities in the chronological order*

# Outline

- **Assembly measurements of the DQW prototype**
  - **Measurement on the associated infrastructures**
  - Workflow (Assembly of the Crab-cavities)
  - Installation of FSI system
  - Validation at warm and cold conditions
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# Measurement on the associated infrastructures

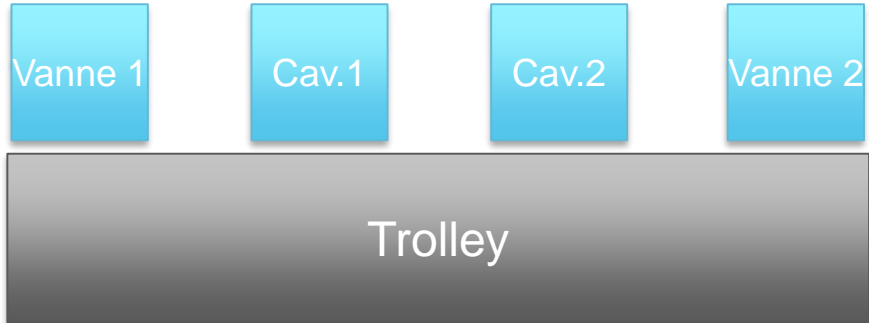
- Trolley
- Gantry crane



# Measurement on the associated infrastructures

- Trolley
- Gantry crane

ISO 5



ISO 4

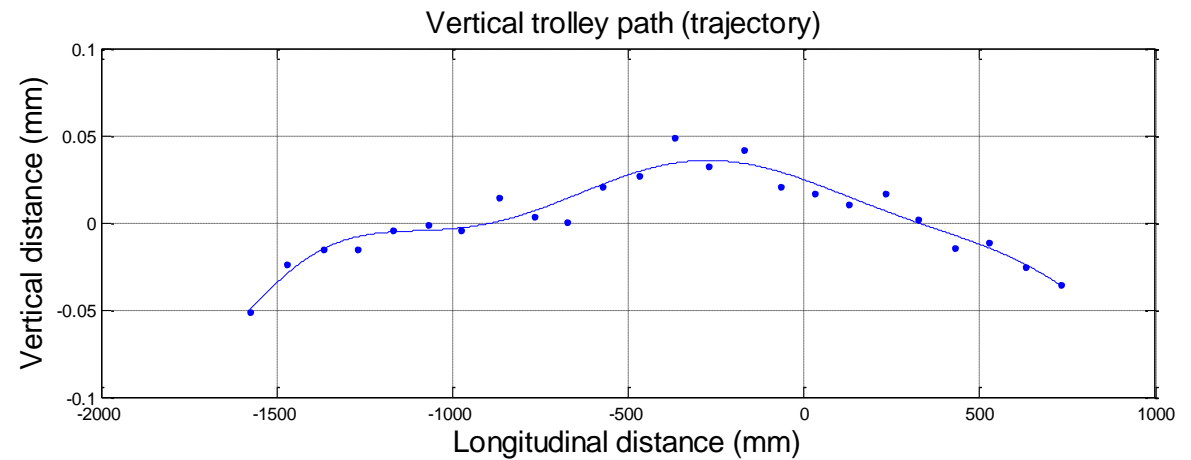
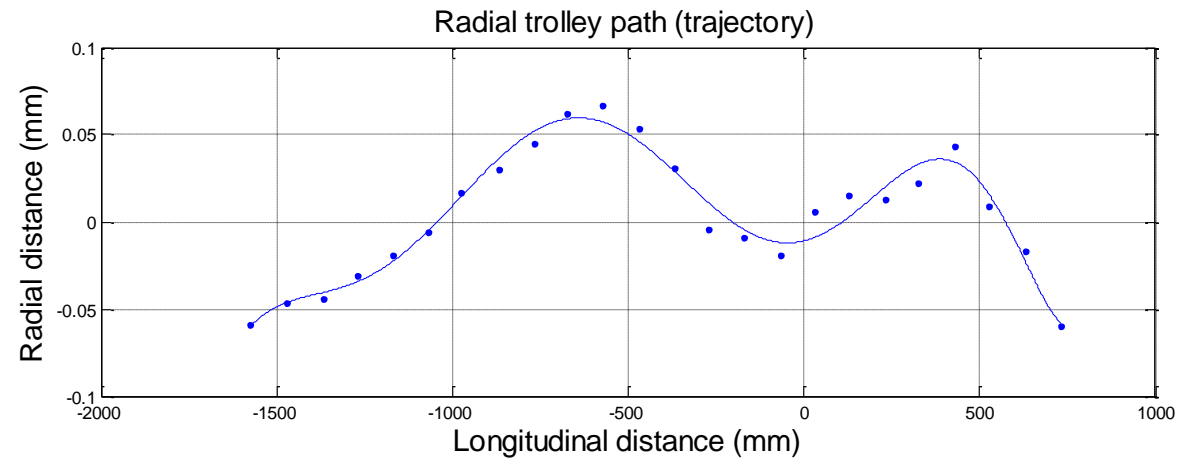


Objective :  
Path of the component (Trajectory) :  
**< 0.1 mm for 1 m of displacement**

# Measurement on the associated infrastructures

- Trolley
- Gantry crane

Objective :  
Path of the component (Trajectory) :  
**< 0.1 mm for 1 m of displacement**



# Measurement on the associated infrastructures

- Trolley
- Gantry crane

Objective :  
Path of the crane (Trajectory) :  
 $< 1 \text{ mm for } 1 \text{ m of displacement}$

Top plate

Vanne 1 Cav.1 Cav.2 Vanne 2

Trolley



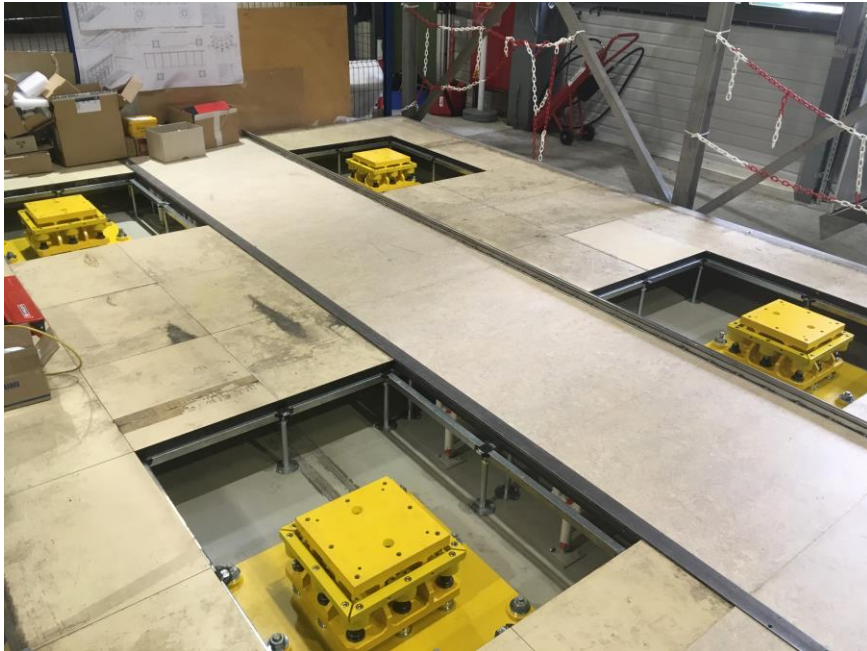
# Measurement on the associated infrastructures

- Trolley
- Gantry crane

Objective :

Path of the crane (Trajectory) :

**< 1 mm for 1 m of displacement**

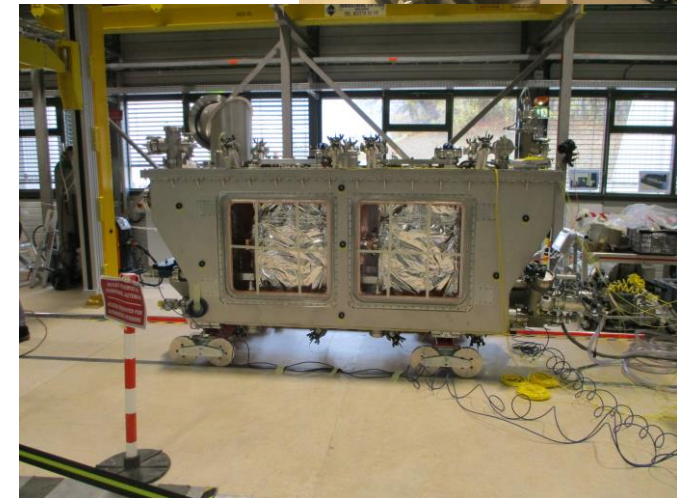
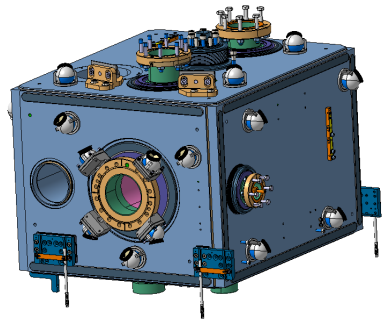
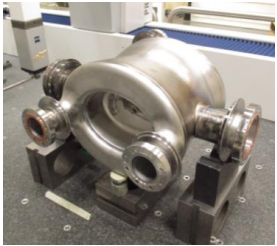


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  - **Workflow (Assembly of the Crab-cavities)**
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  - Extrapolate to the RFD prototype
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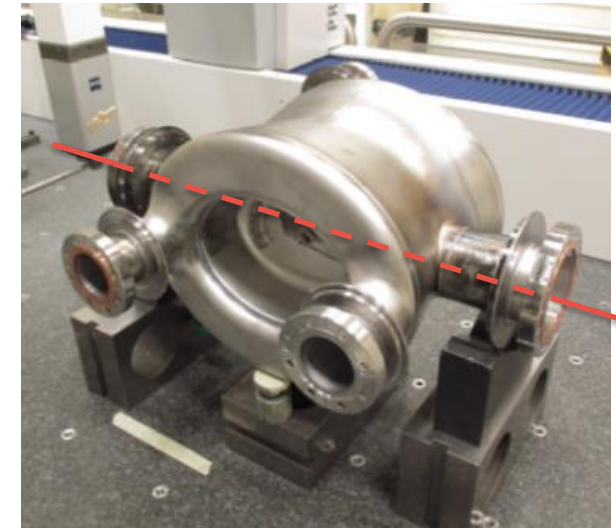
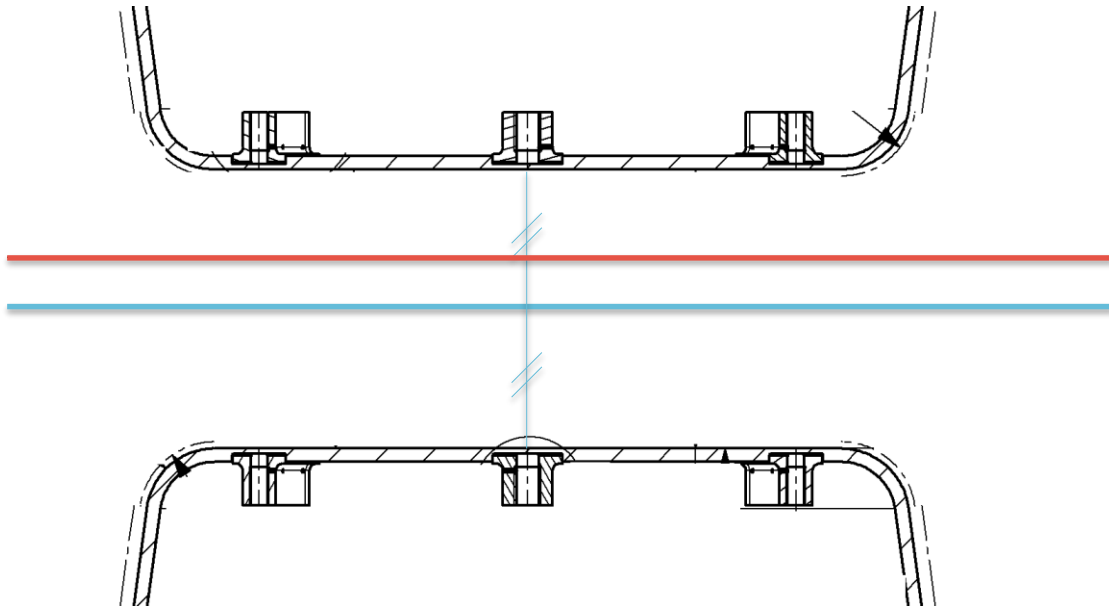
# Workflow (Assembly of the Crab-cavities)

- Determination of the mechanical axis → Capacitive plate of the cavities
- Fiducialisation of the Dressed Cavities
- String line assembly in clean room
- Installation of the others components on the string line
- Final alignment of the string line
- Installation of the top plate (supporting plate of the string line)
- Insertion of string line in the cryomodule



# Workflow (Assembly of the Crab-cavities)

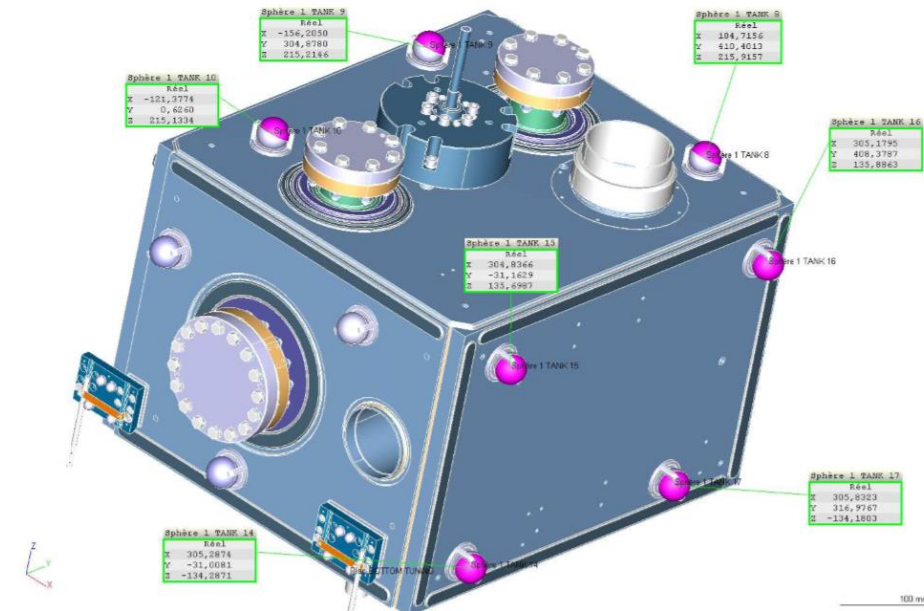
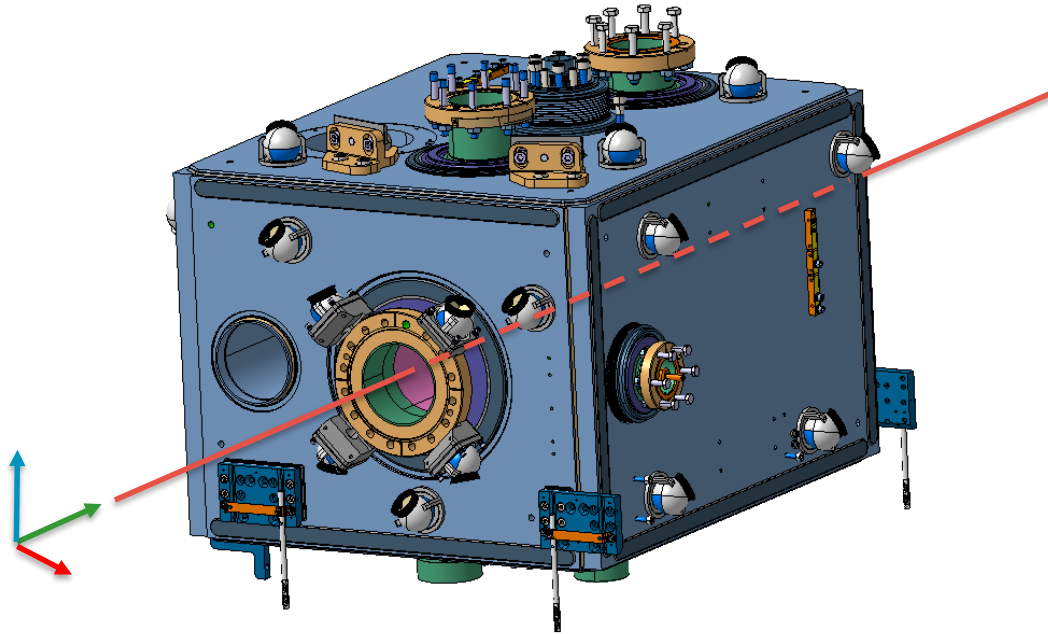
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Metrology step	Cavity 1	Cavity 2
Before treatment	-0.691	-0.291
After treatment	-0.673	No metrology
After tuning	-0.661	-0.165
Capacitive plate : Pins check	-0.553	No metrology
<b>After tank welding</b>	<b>-0.557</b>	<b>-0.040</b>

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## 3D measurement of :

- Mechanical axis
- Position of FPC, Coupler, Tuner, ...
- FSI targets
- BCAM targets
- Laser Tracker targets

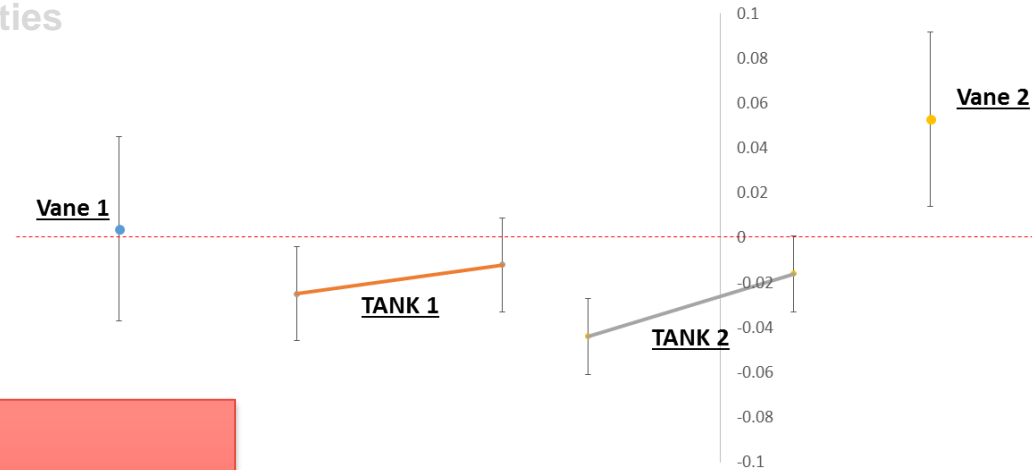
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## Objective / Results :

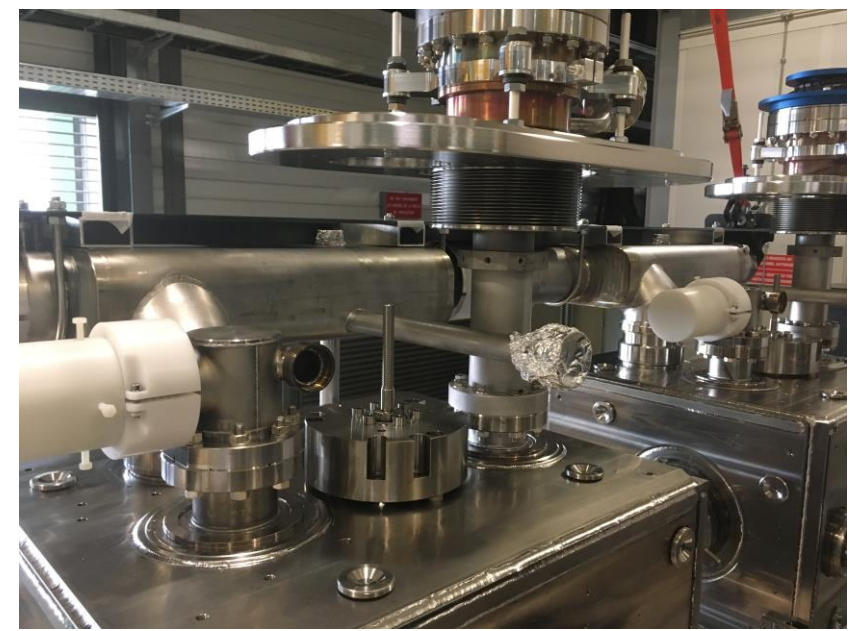
- Alignment before the assembly :  $< 0.1$  mm (regression line)
- Control the alignment after the assembly :  $< 0.2$  mm (regression line)
- Impact of vacuum on the string line :  $< 0.1$  mm

Vertical displacement between :  
Without vacuum and under vacuum



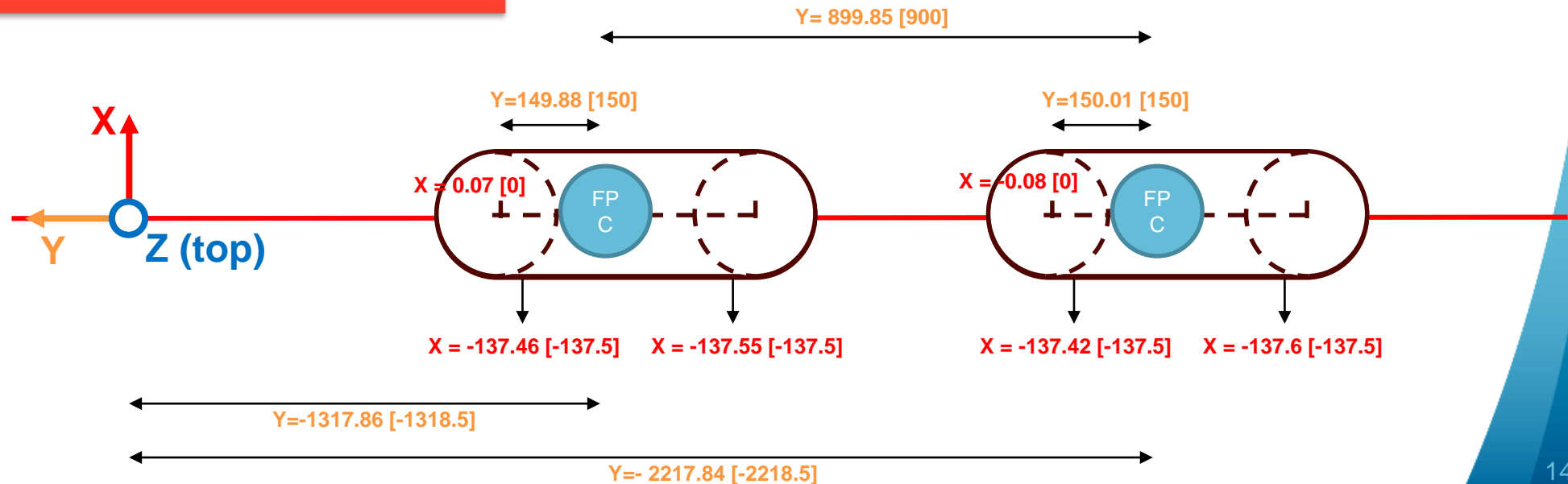
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## Objective / Results :

- Cryogenic line : at 1 mm
- Oblong bellows plate : at 1 mm
- ...

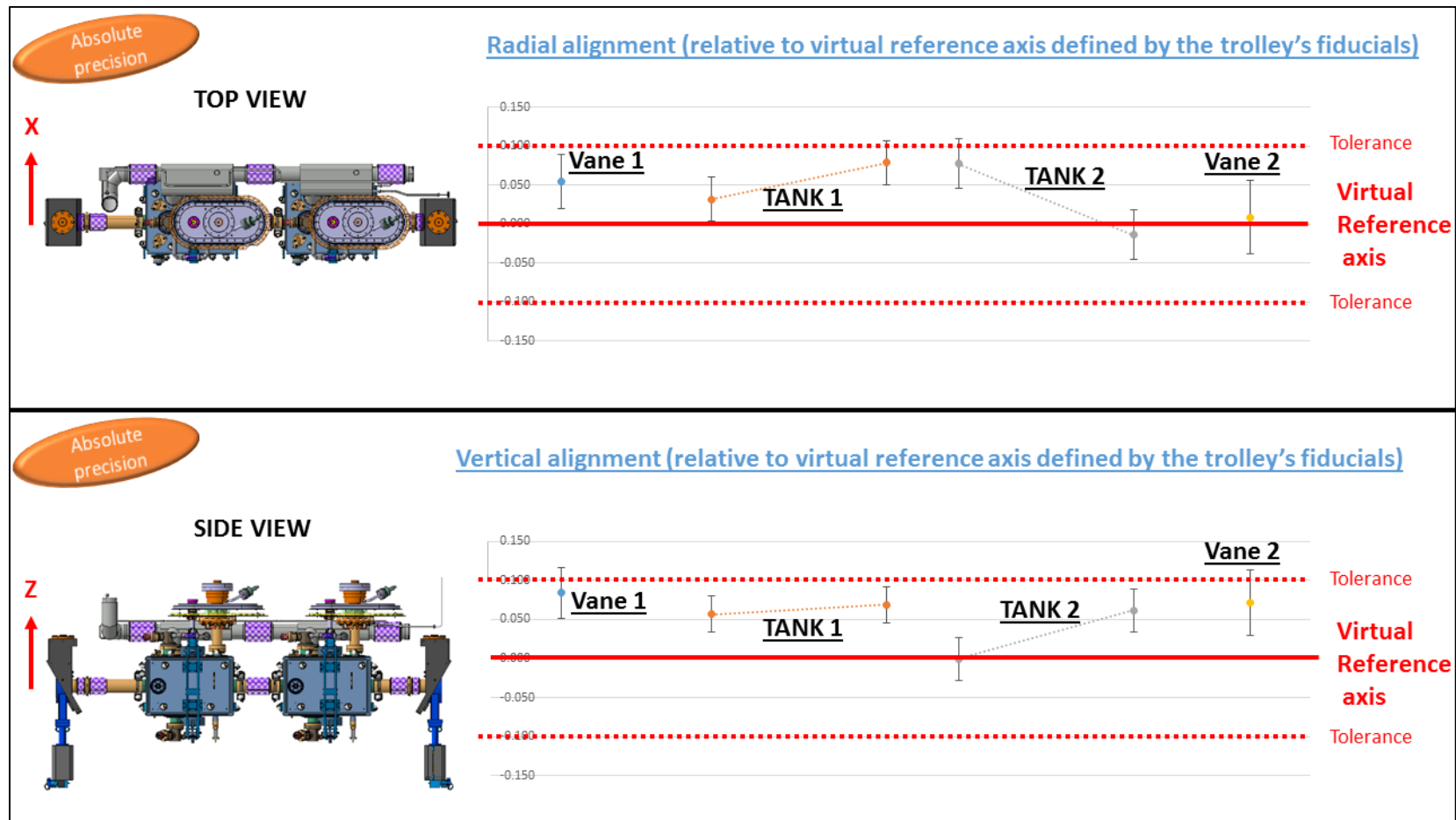


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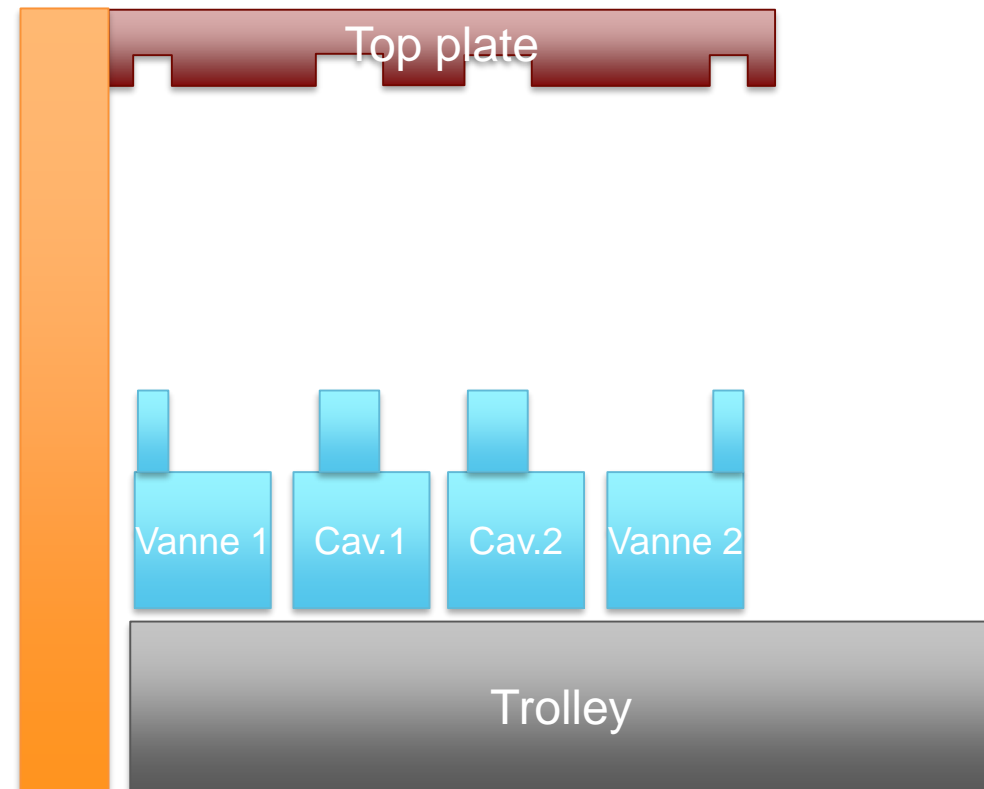
## Objective / Results :

- Alignment :  $< 0.1$  mm



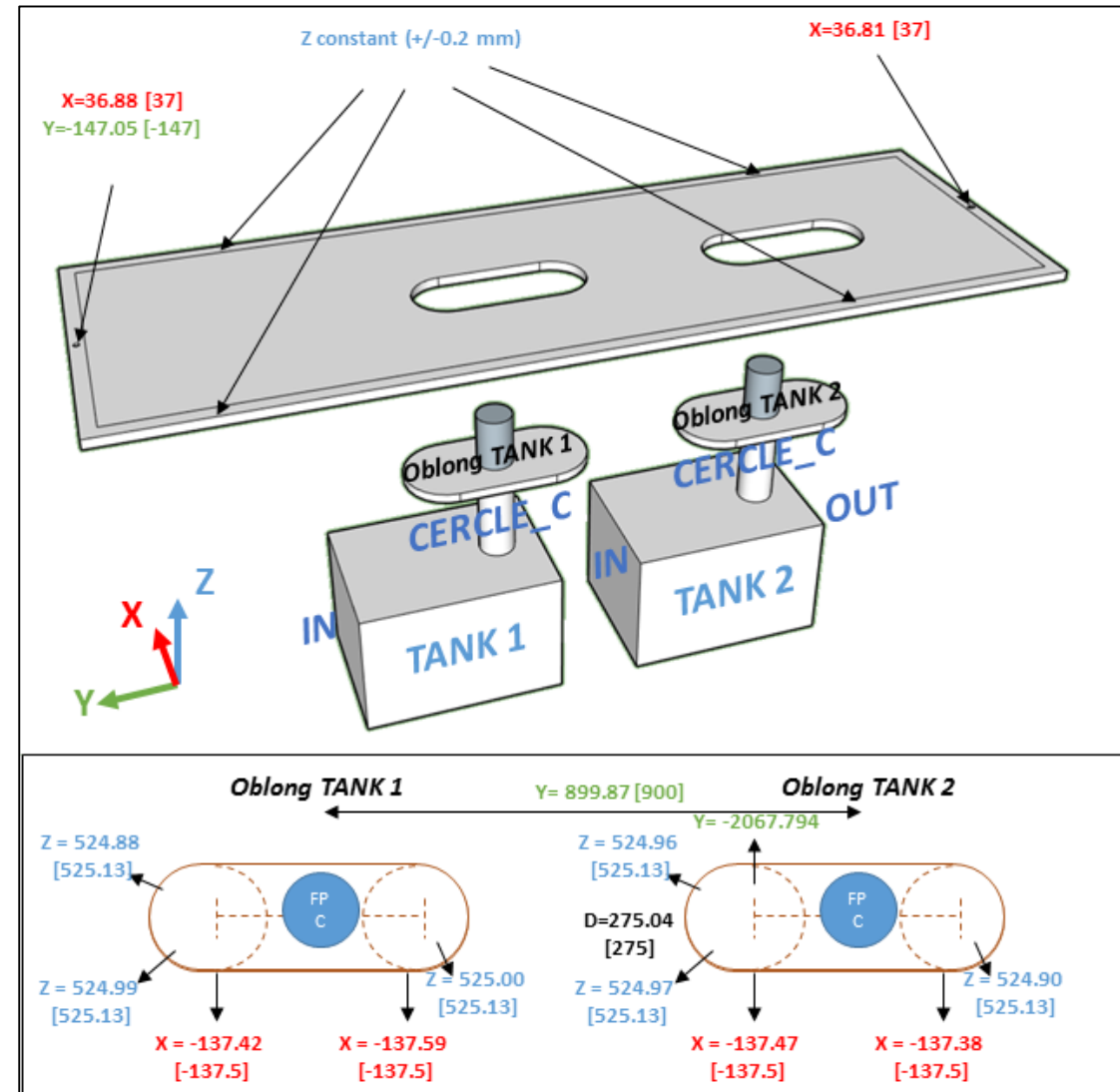
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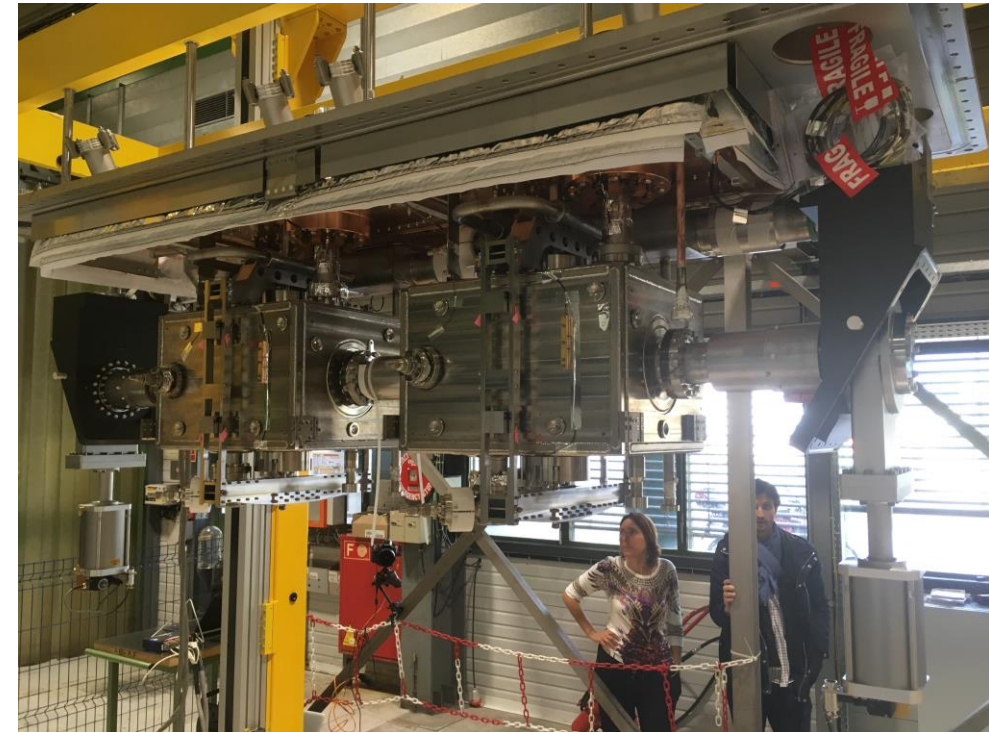
## Objective / Results :

- Installation of the top plate : at 0.2 mm
- Installation of the string line : at 0.2 mm
- Taking into account the trajectory of the gantry crane



# Workflow (Assembly of the Crab-cavities)

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- Installation of the top plate (supporting plate of the string line)
- **Insertion of string line in the cryomodule**

## Objective / Results :

- Installation of the cryomodule: at 0.2 mm
- Taking into account the trajectory of the gantry crane



# Outline

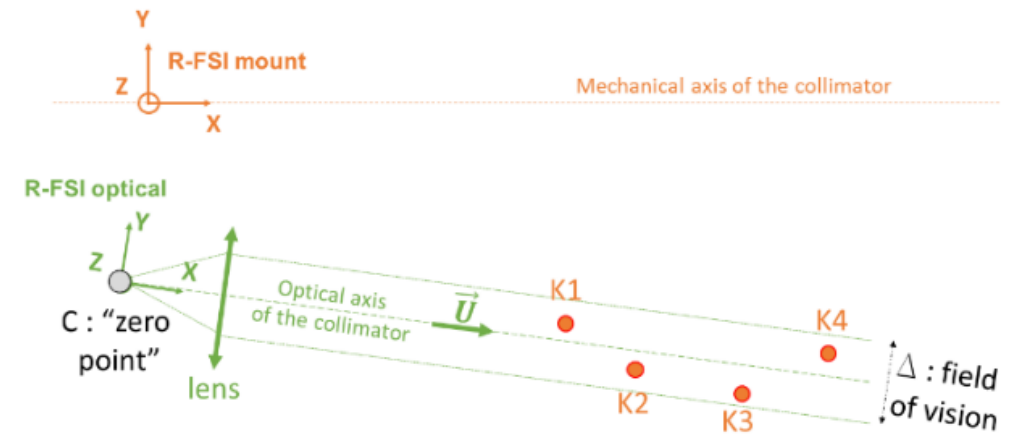
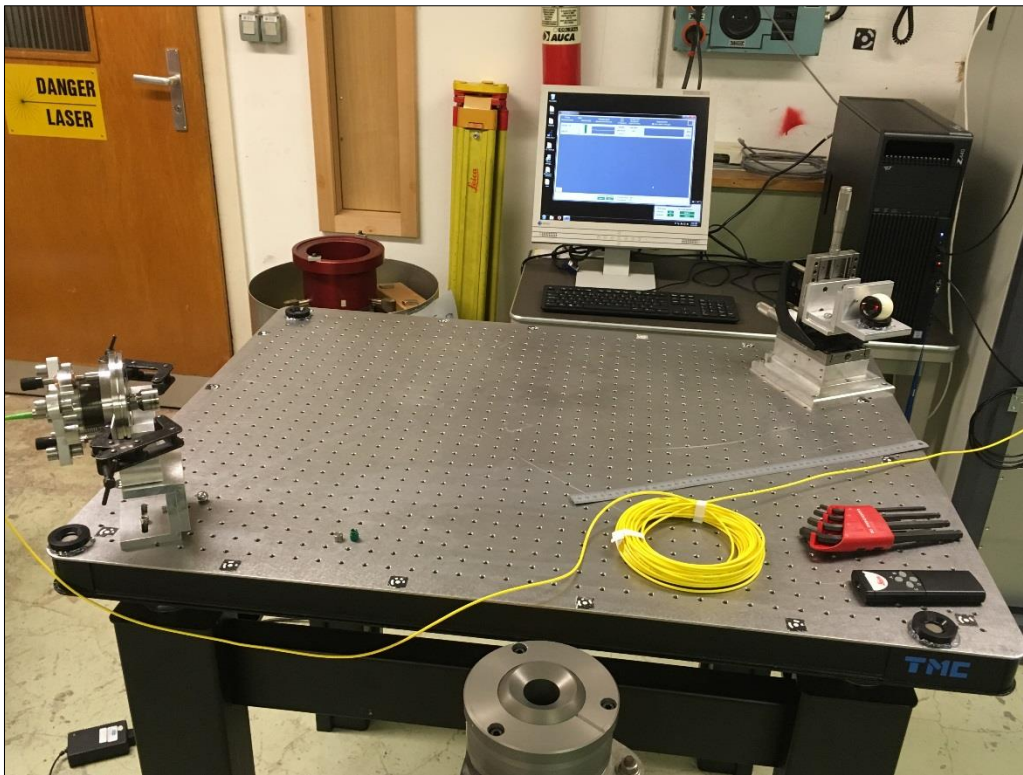
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# Installation of FSI system

- Calibration of FSI feedthrough
- Installation of FSI feedthrough on the cryomodule
- Installation of FSI targets

## Objective / Results :

- Calibration : < 0.01 mm



[C-Ki] : Measured distance with FSI

$$\begin{pmatrix} X_{K_i} \\ Y_{K_i} \\ Z_{K_i} \end{pmatrix} = \begin{pmatrix} X_C \\ Y_C \\ Z_C \end{pmatrix} + \begin{pmatrix} U_X \\ U_Y \\ U_Z \end{pmatrix} * Dist_i$$

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## Objective / Results :

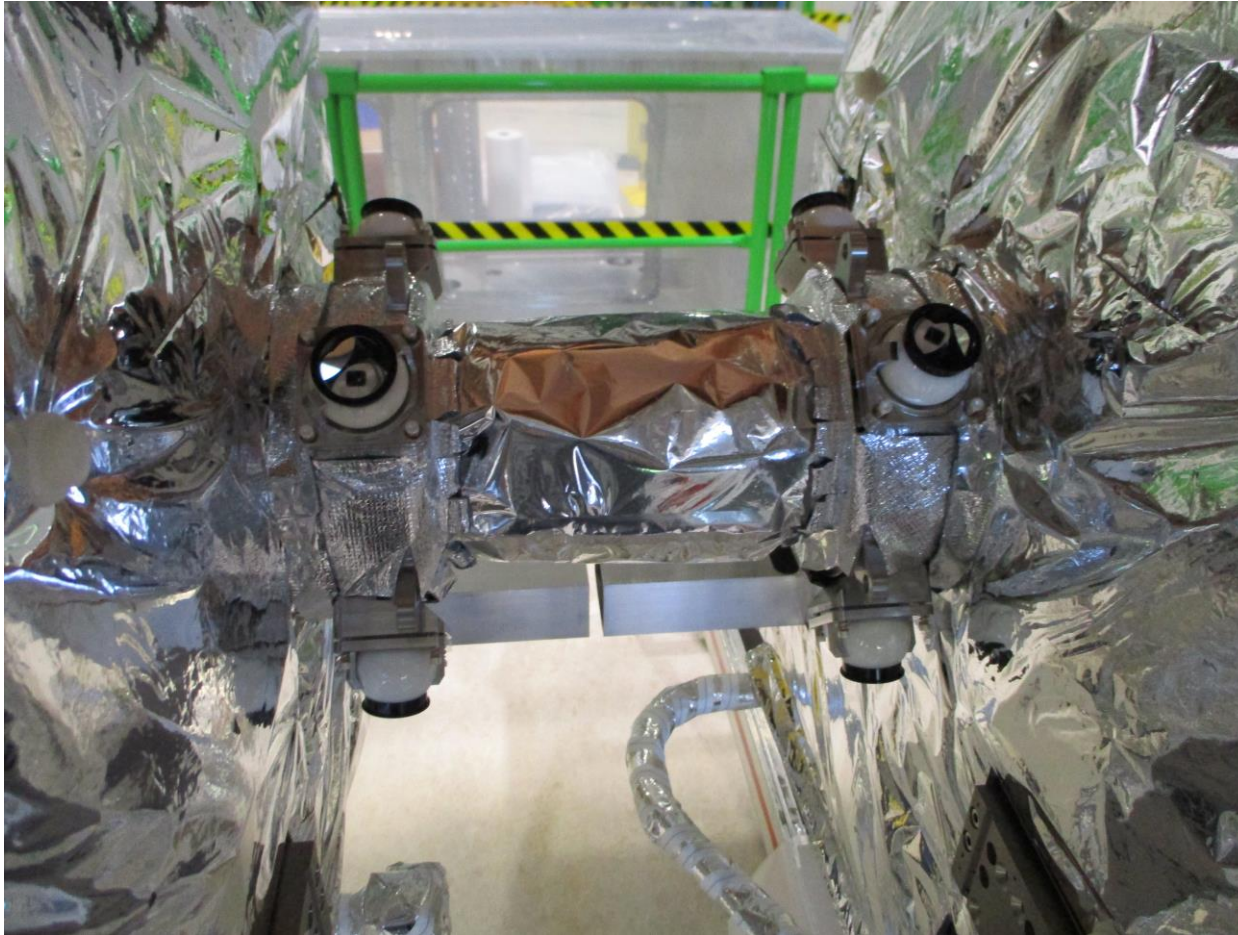
- Accuracy :  $< 0.02 \text{ mm}$

## 3D measurement of :

- Cryomodule
- FSI feedthrough

# Installation of FSI system

- Calibration of FSI feedthrough
- Installation of FSI feedthrough on the cryomodule
- **Installation of FSI targets**



## Objective / Results :

- Accuracy :  $< 0.02 \text{ mm}$

## 3D measurement of :

- Dressed cavities
- FSI targets

# Outline

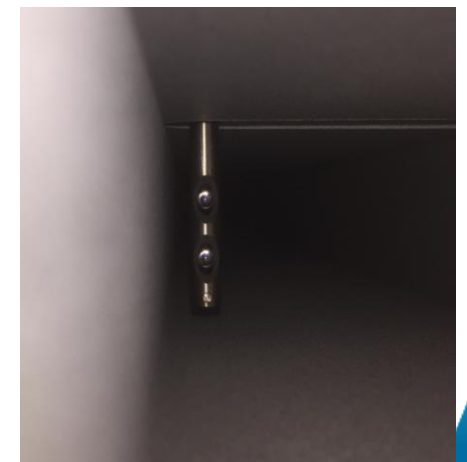
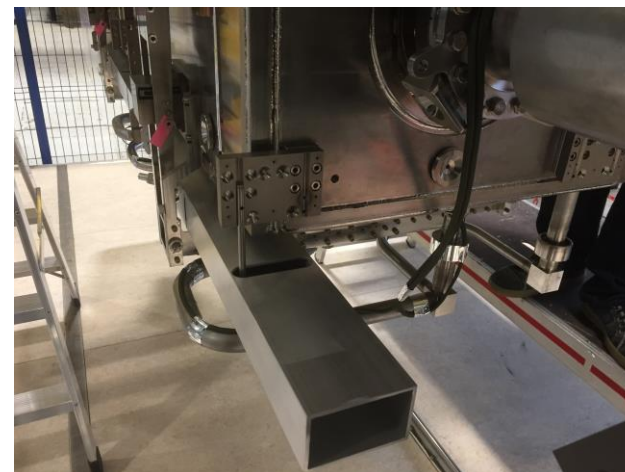
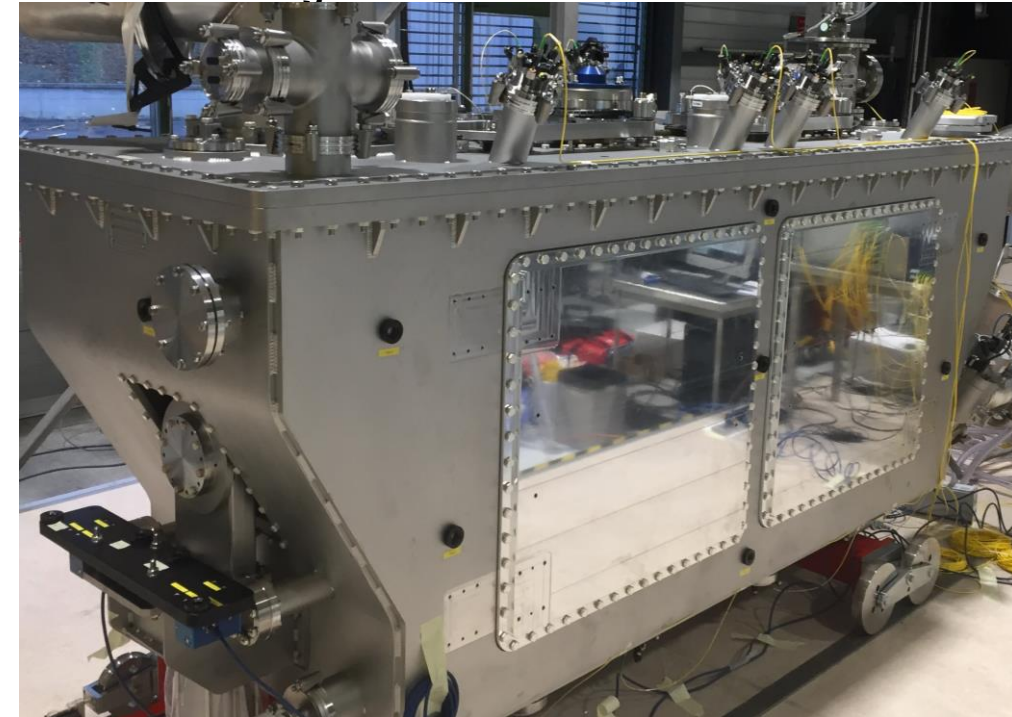
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# Validation at warm and cold conditions

- Installation of an alternative monitoring system (BCAM system) → For Cross-checking measurement
- Validation at warm
- Impact of vacuum on the string line
- Impact of transport on the string line
- Validation at cold condition

## Objective / Results :

- 3D measurement of the supporting plate for the BCAM :  $< 0.02$  mm
- Installation of the supporting plate on the cryomodule :  $< 0.02$  mm
- Installation of BCAM targets
- Installation of BCAM window

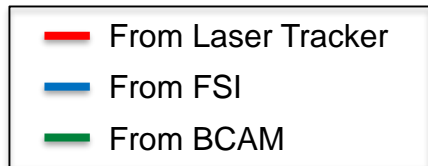


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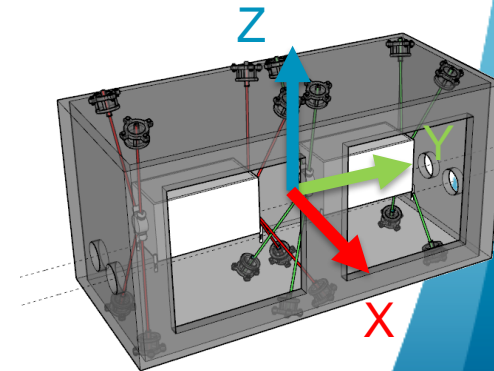
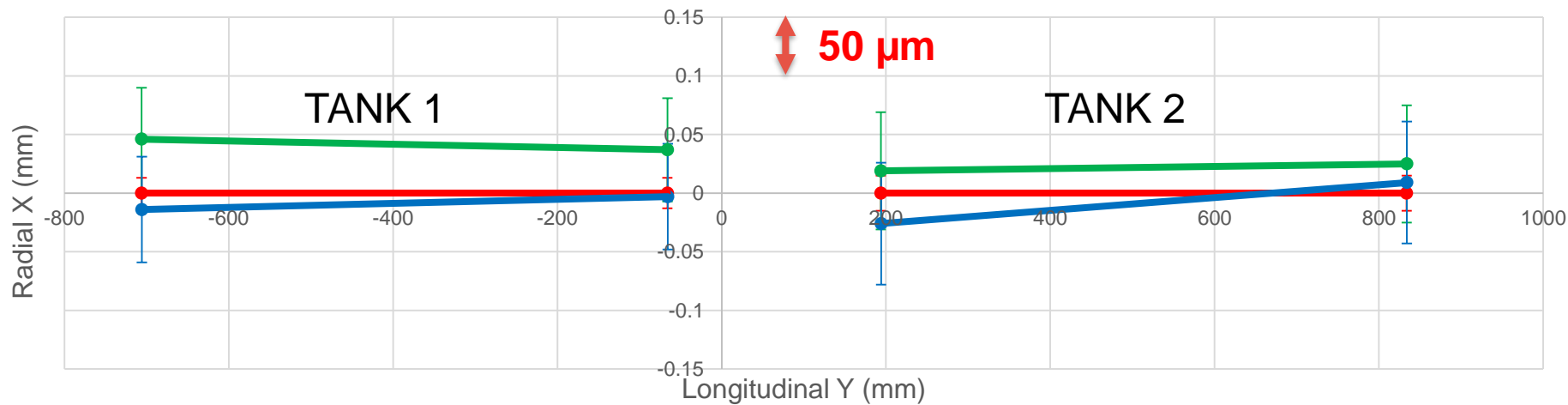
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- Impact of vacuum on the string line
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- Validation at cold condition

**Objective / Results :**

- Intercomparison :  $< 0.05 \text{ mm}$



Radial position (relatif with respected to AT401 measurement)

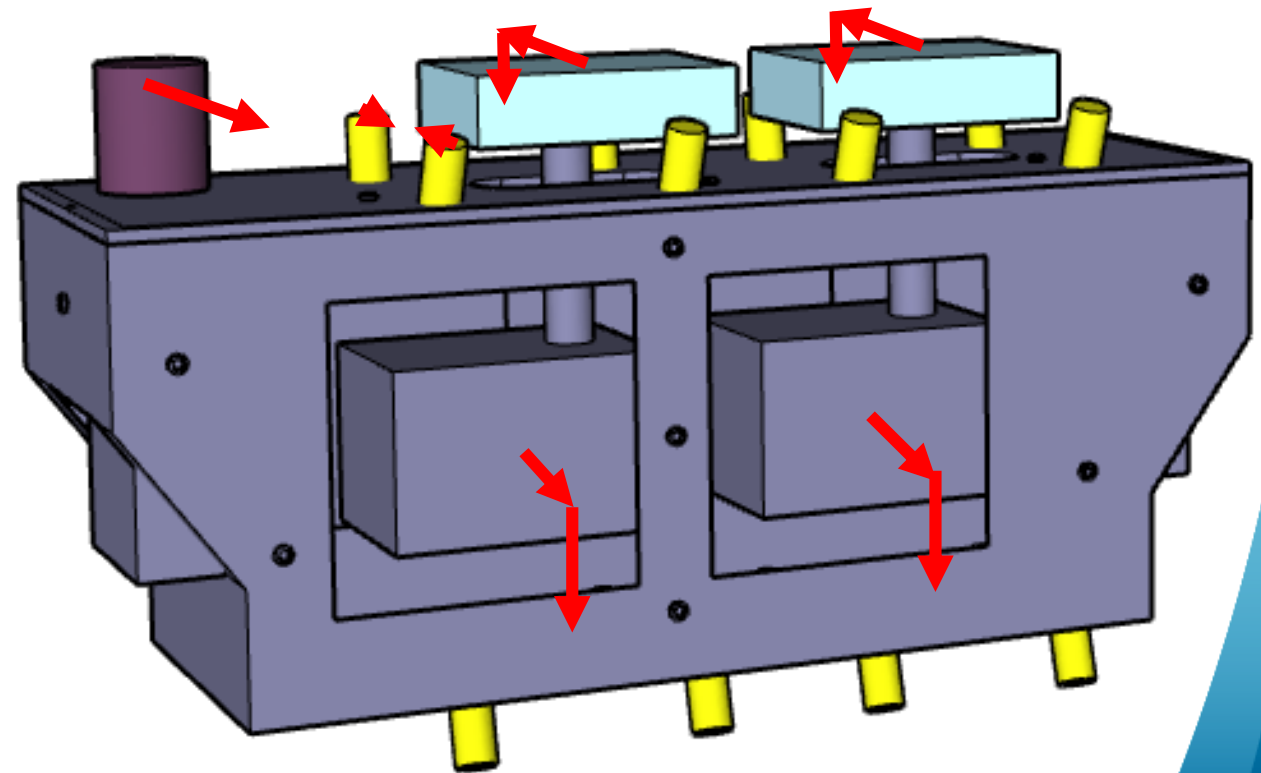


# Validation at warm and cold conditions

- Installation of an alternative monitoring system (BCAM system) → For Cross-checking measurement
- Validation at warm
- **Impact of vacuum on the string line**
- Impact of transport on the string line
- Validation at cold condition

## Objective / Results :

- Impact of vacuum on the jumper : up to 0.3 mm
- Impact of vacuum on the Cryomodule : up to 0.7 mm
- Impact of vacuum on the Couplers : up to 0.2 mm
- Impact of vacuum on the dressed cavities : up to 0.2 mm



# Validation at warm and cold conditions

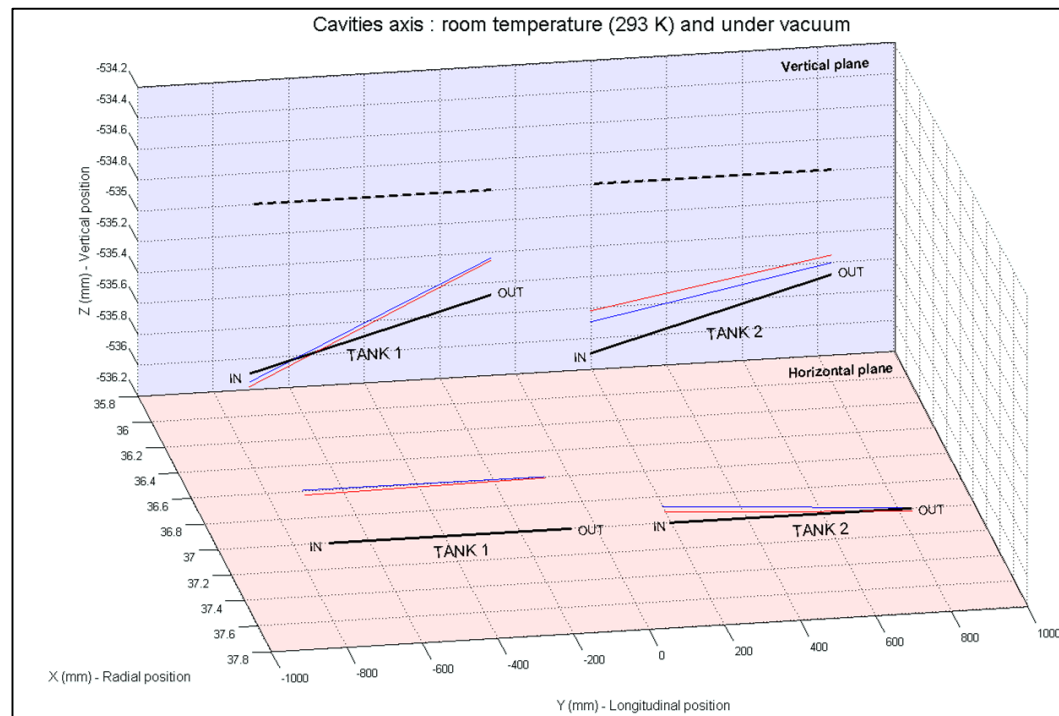
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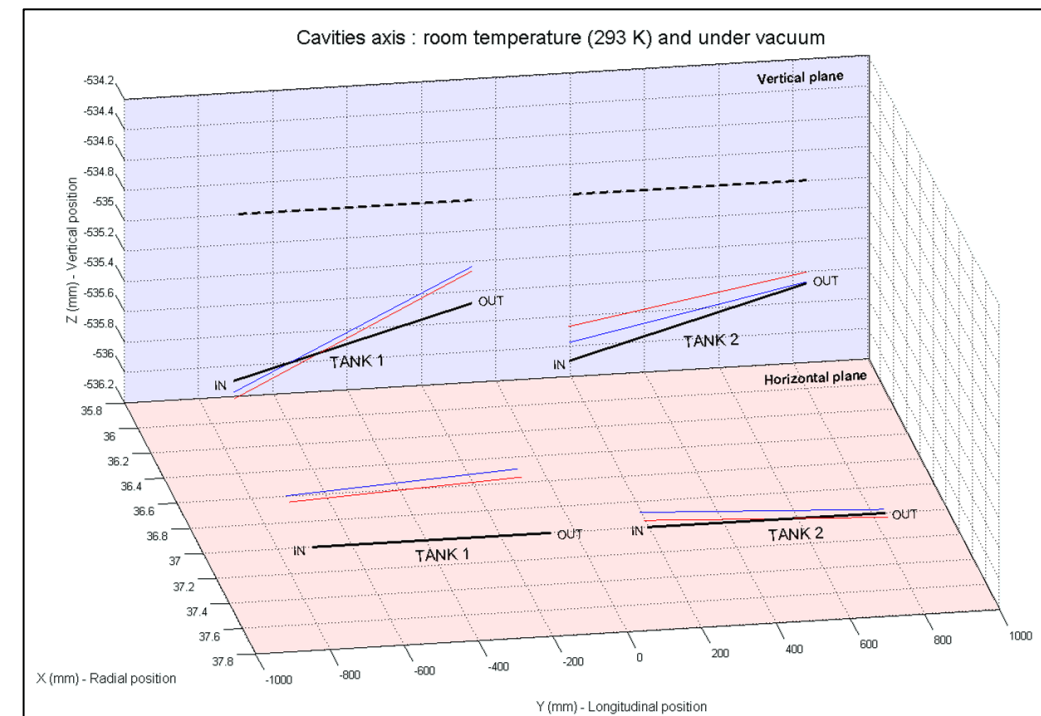
- Impact of transport :  $< 0.05 \text{ mm}$



## BEFORE TRANSPORT



## AFTER TRANSPORT



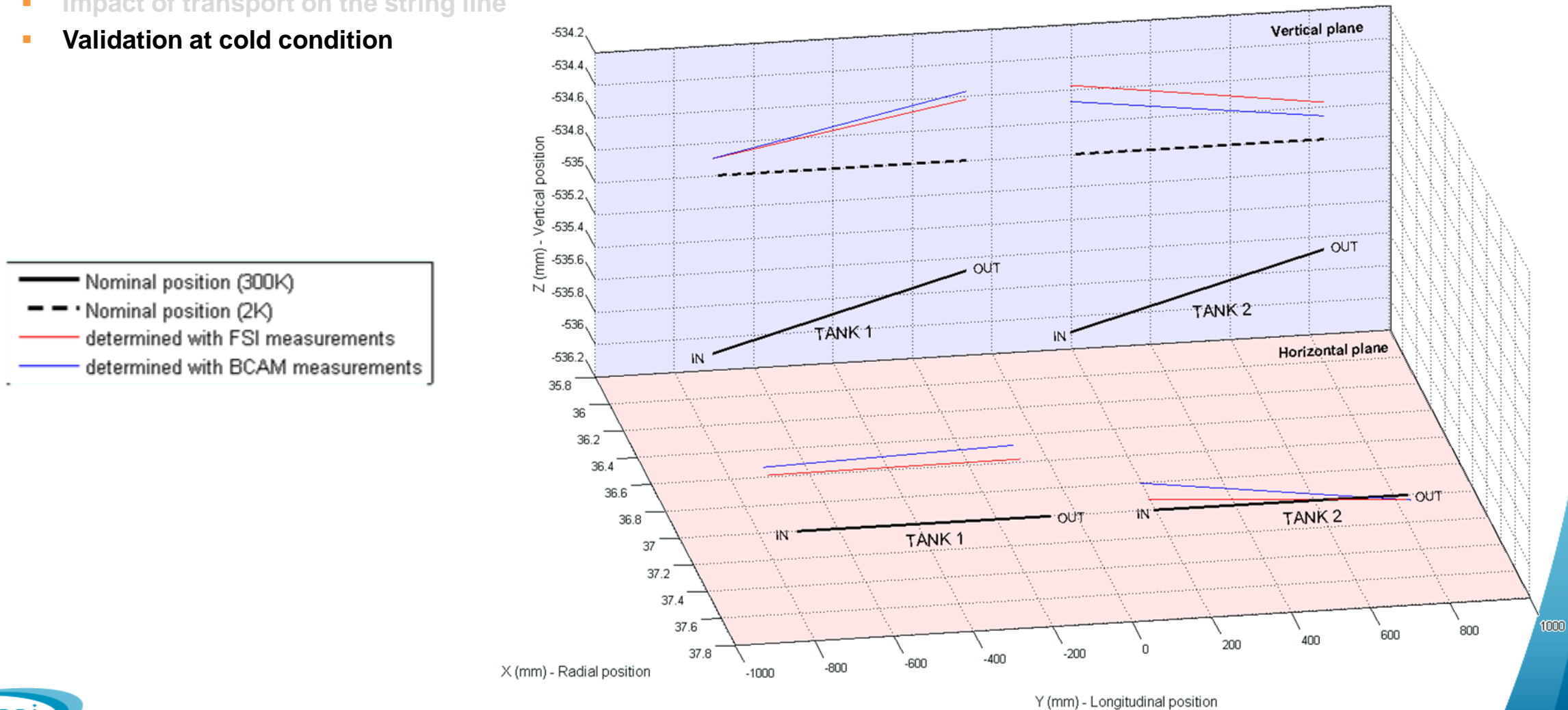
- Nominal position (300K)
- - - Nominal position (2K)
- determined with FSI measurements
- determined with BCAM measurements

# Validation at warm and cold conditions

- Installation of an alternative monitoring system (BCAM system)
- Validation at warm
- Impact of vacuum on the string line
- Impact of transport on the string line
- **Validation at cold condition**

## Objective / Results :

- Intercomparison :  $< 0.05$  mm



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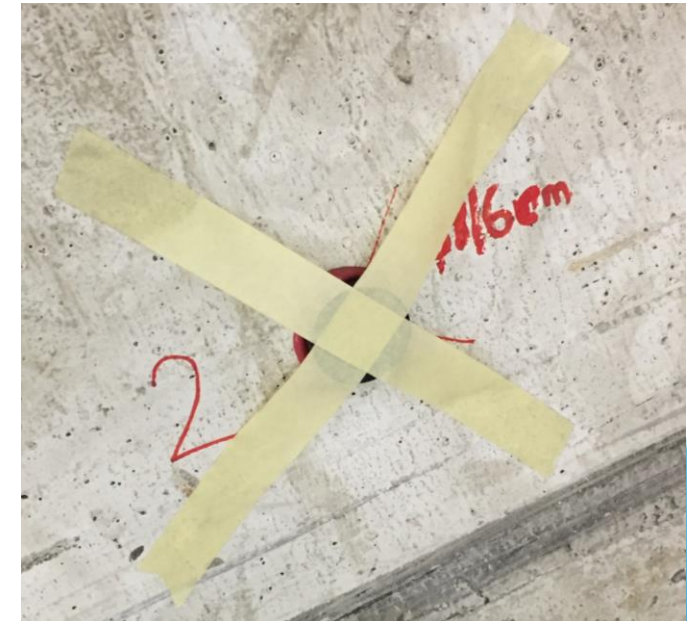
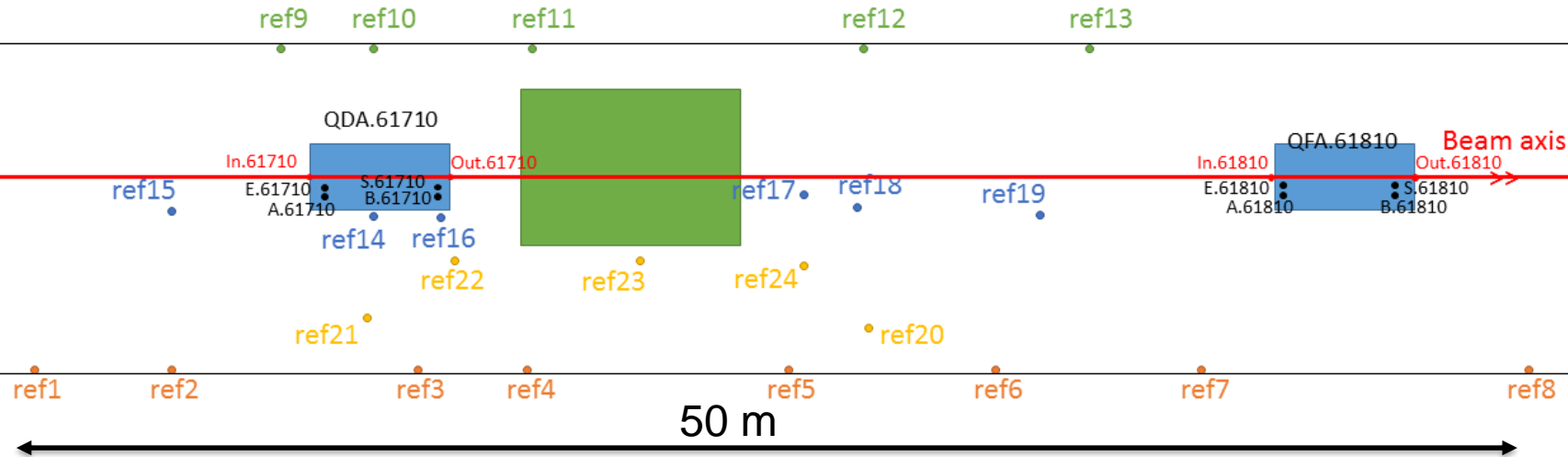
# Installation of the DQW prototype in SPS tunnel

- Definition and determination of a local network
- Implantation and marking
- Validation and installation of the SPS tunnel table
- Installation of cryomodule
- Long term follow up (using FSI measurement)

## Objective / Results :

- Accuracy : < 0.15 mm

## Synoptic of network points

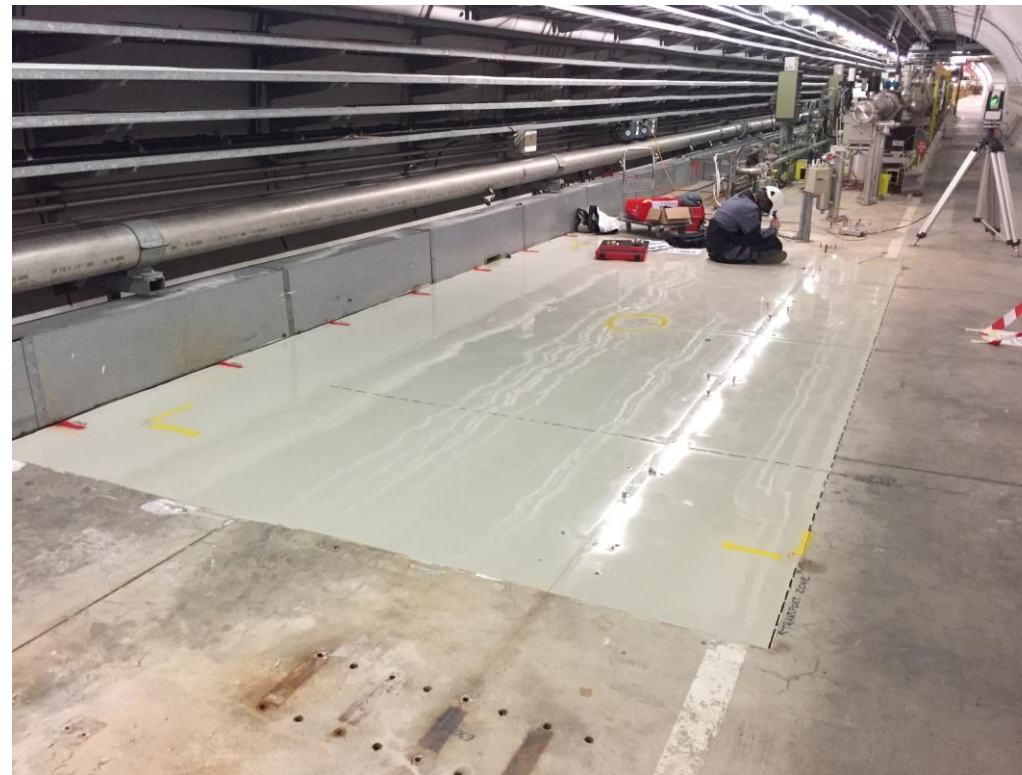


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- Definition and determination of a local network
- **Implantation and marking**
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## Objective / Results :

- Accuracy : few mm

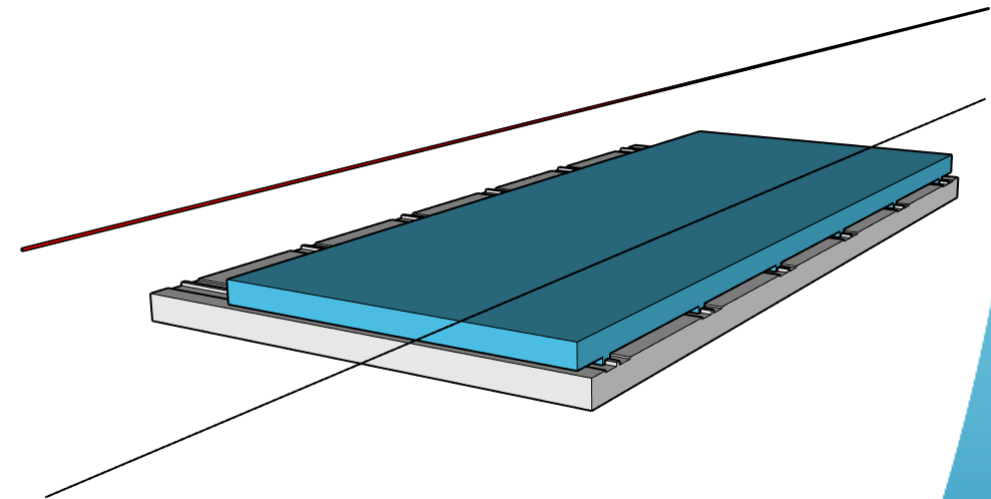
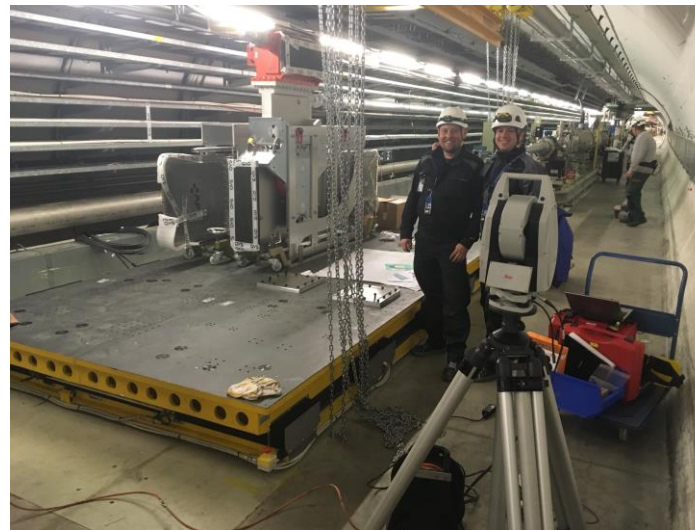


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- **Validation and installation of the SPS tunnel table**
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- Long term follow up (using FSI measurement)

## Objective / Results :

- Installation of SPS tunnel table : few mm

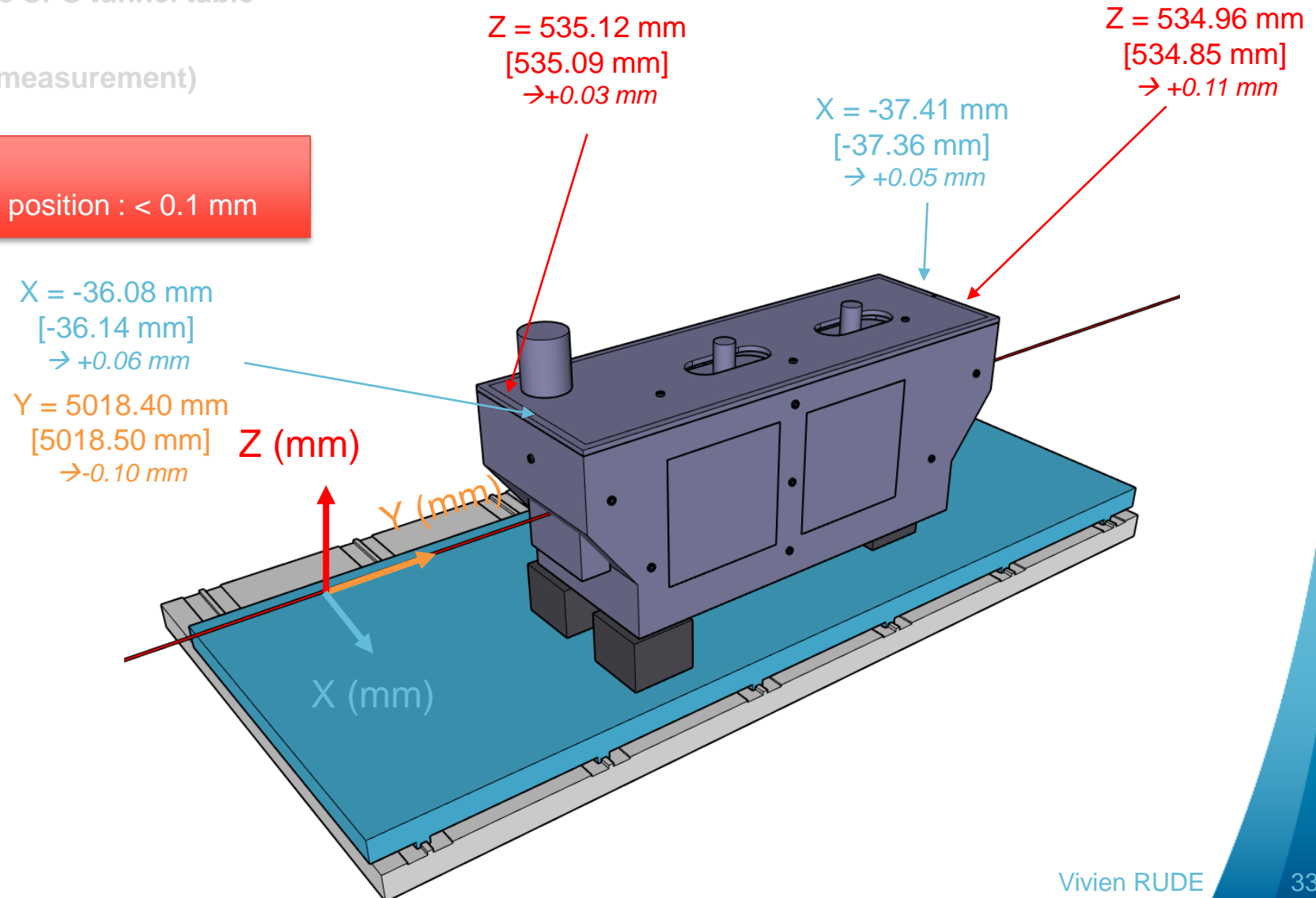


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## Objective / Results :

- Installation of cryomodule w.r.t. the nominal position :  $< 0.1$  mm

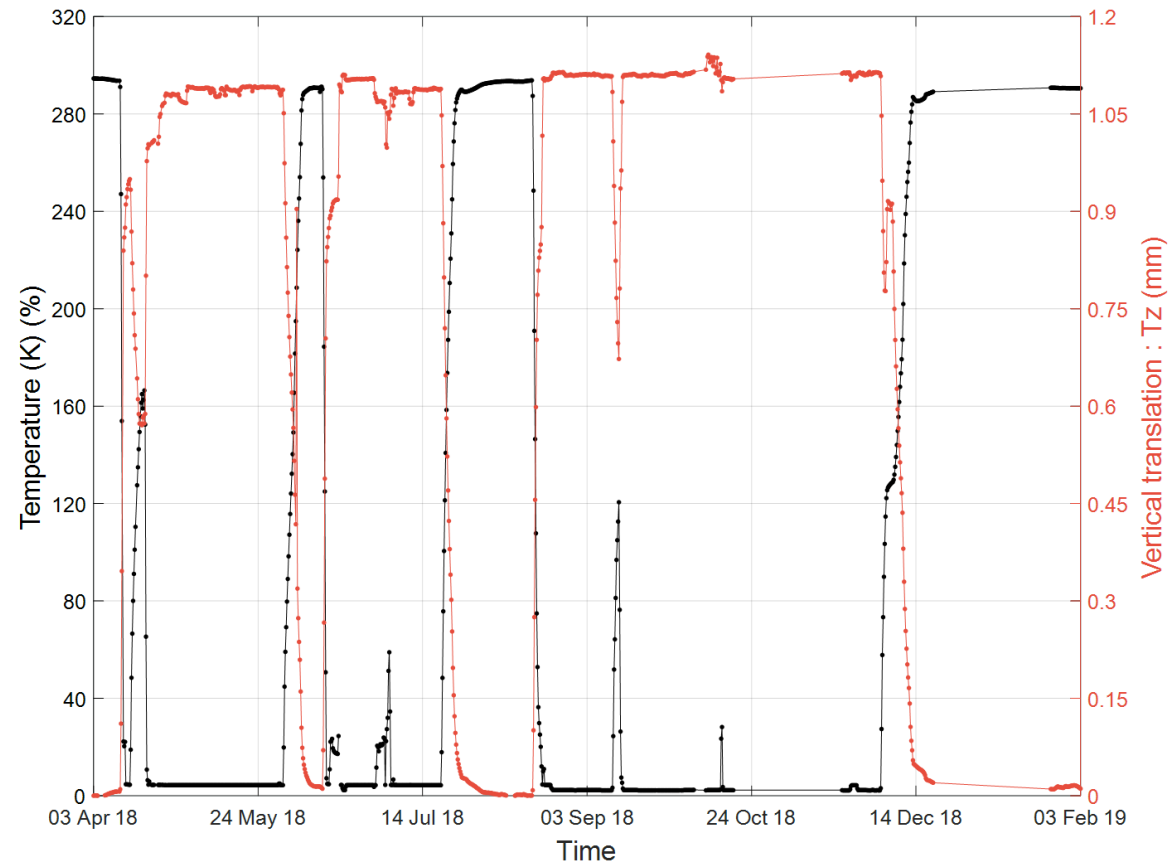


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## Objective / Results :

- Repeatability: < 0.02 mm



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- 
- **For the assembly of the RFD prototype and the 10 series, the same assembly steps will have to be followed**
  - **In the LHC, no installation of translation table is foreseen**
  - **All measurements were documented.**
  - **Procedures for transfer knowledge are under preparation and we will assist the collaborators for the keys steps**

Thank you  
for your attention