Specific Case : Crab-cavities

Alignment review 2019

Vivien RUDE

2019-08-26

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*

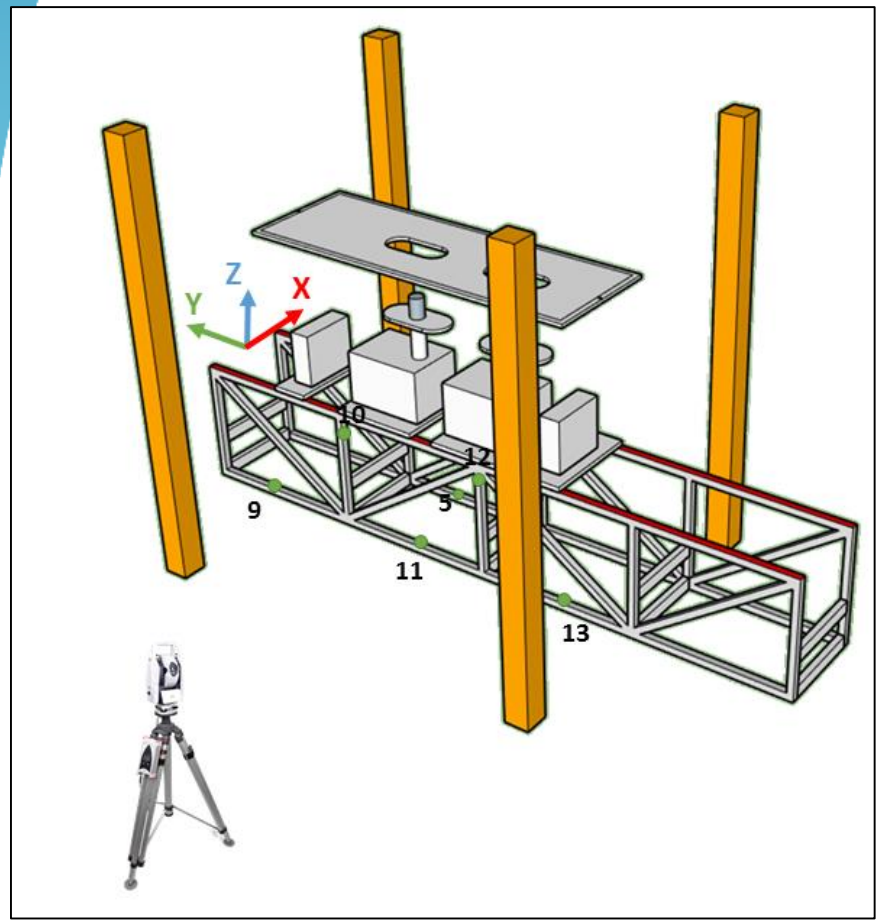
Outline

- **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
  - 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)

Measurement on the associated infrastructures

- Trolley
- Gantry crane



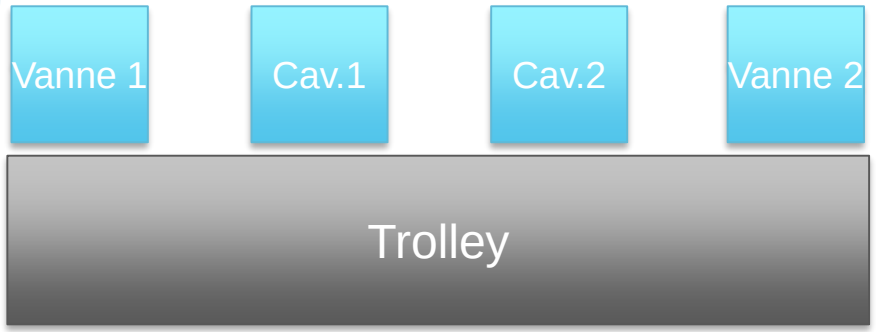
Measurement on the associated infrastructures

- **Trolley**
- Gantry crane

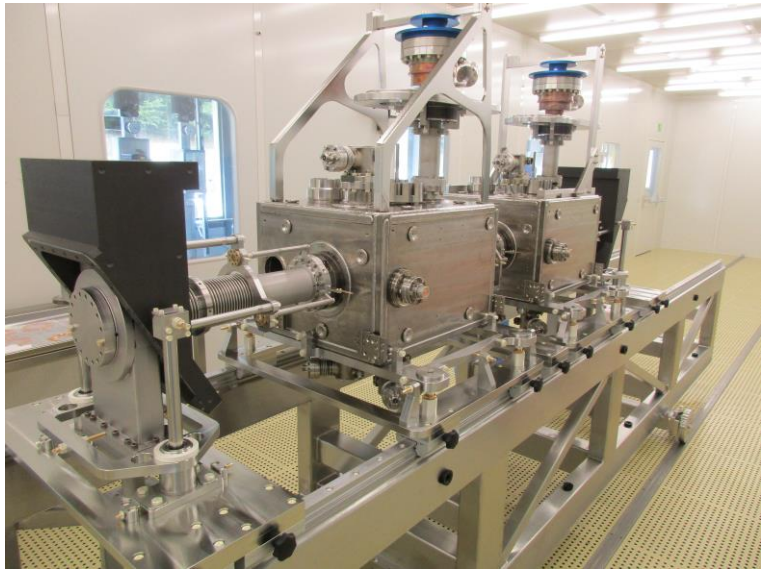
Objective :
Path of the component (Trajectory) :

< 0.1 mm for 1 m of displacement

ISO 5



ISO 4

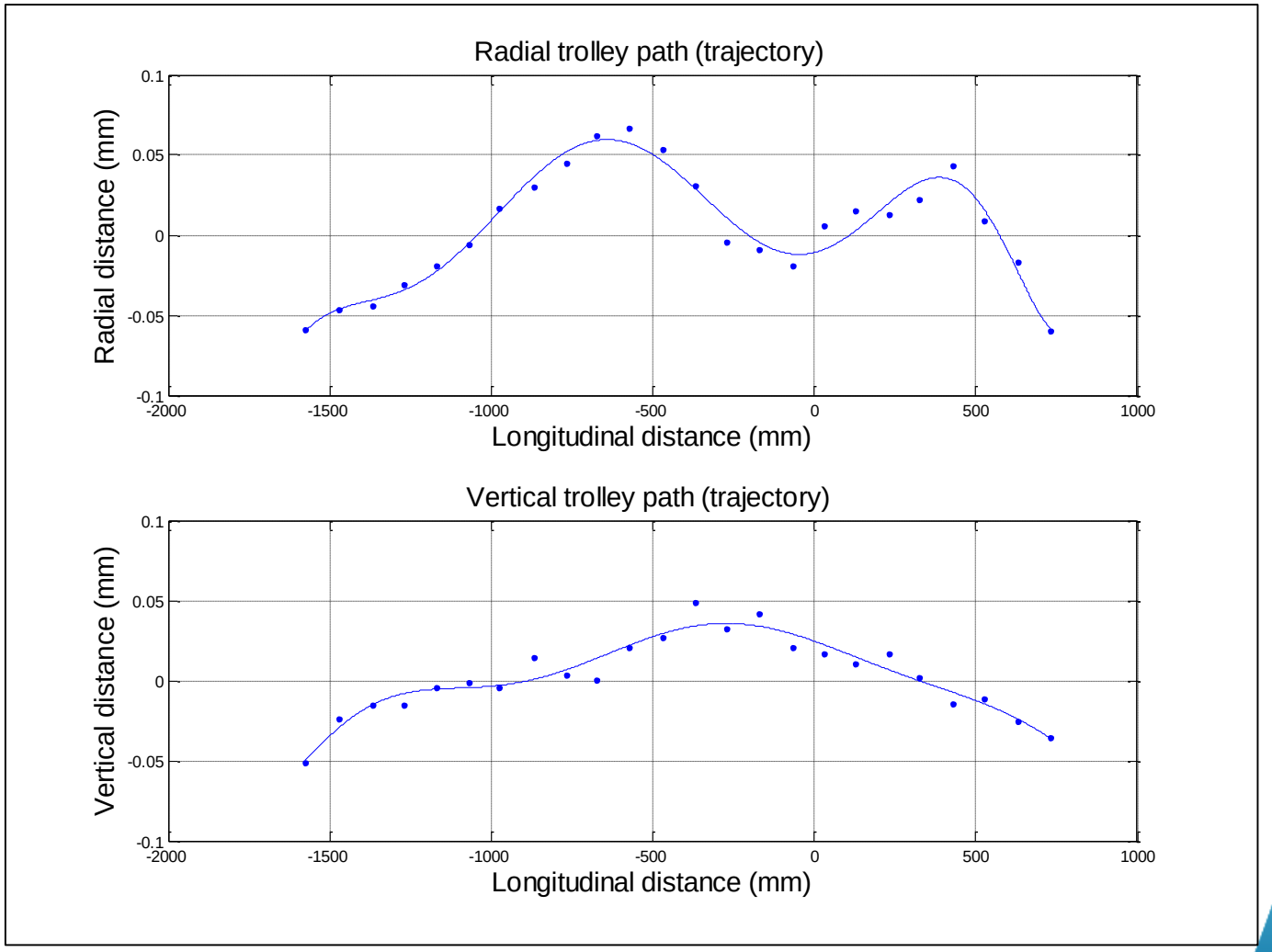


Measurement on the associated infrastructures

- **Trolley**
- Gantry crane

Objective :
Path of the component (Trajectory) :

< 0.1 mm for 1 m of displacement

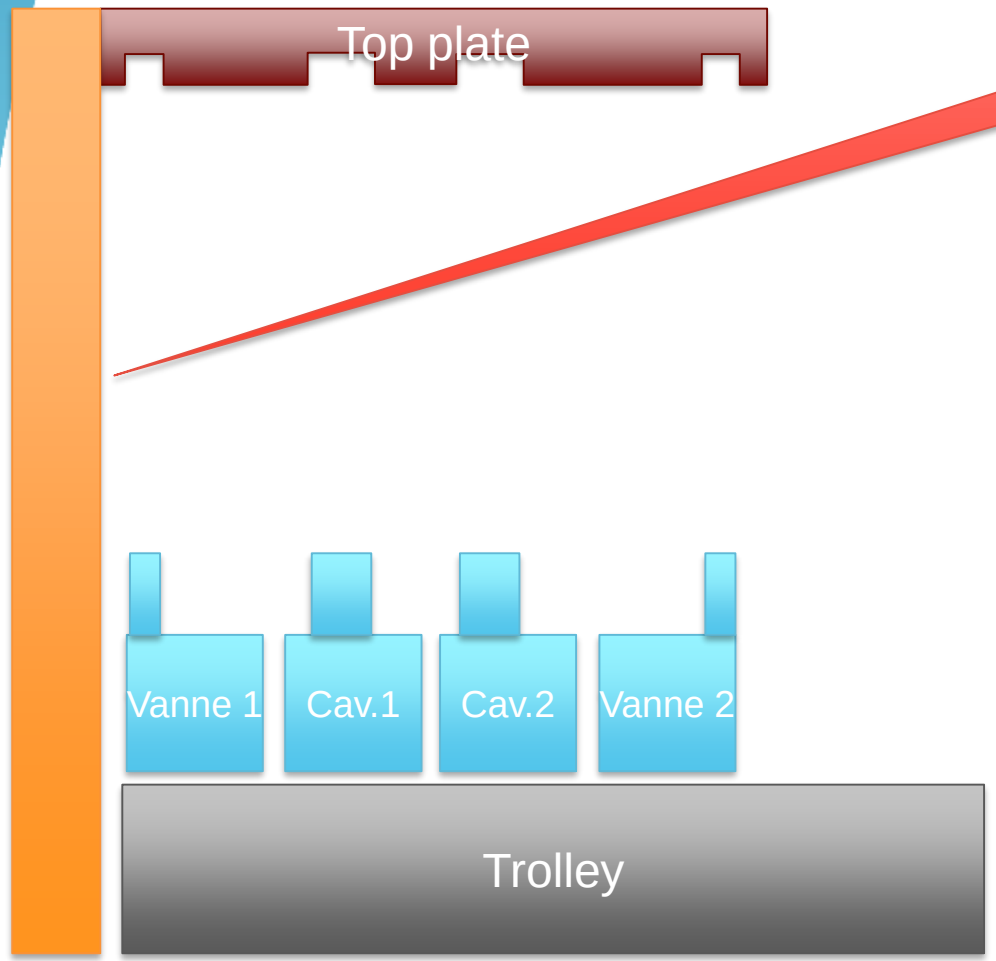


Measurement on the associated infrastructures

- Trolley
- **Gantry crane**

Objective :
Path of the crane (Trajectory) :

< 1 mm for 1 m of displacement

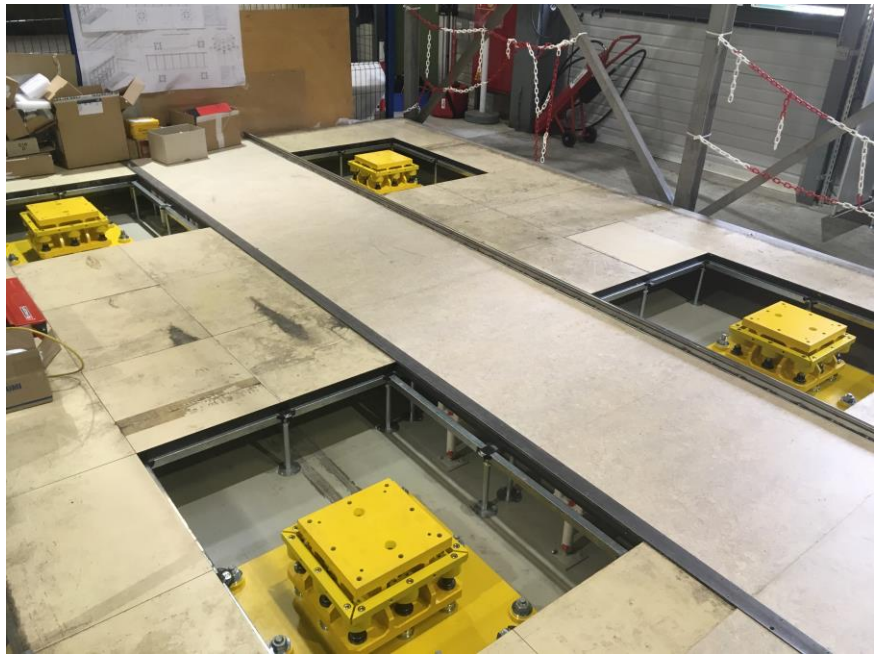


Measurement on the associated infrastructures

- Trolley
- **Gantry crane**

Objective :
Path of the crane (Trajectory) :

< 1 mm for 1 m of displacement



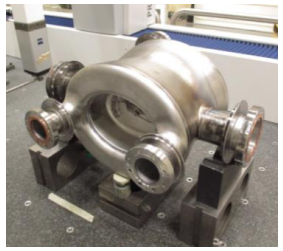
Outline

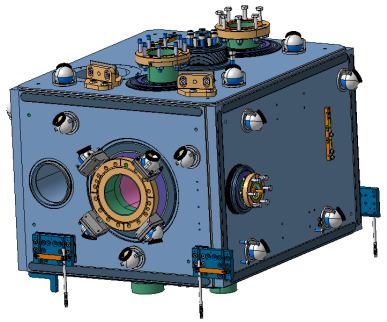
- **Assembly measurements of the DQW prototype**
  - Measurement on the associated infrastructures
  - **Workflow (Assembly of the Crab-cavities)**
  - Installation of FSI system
  - Validation at warm and cold conditions
  - Installation of the DQW prototype in SPS tunnel

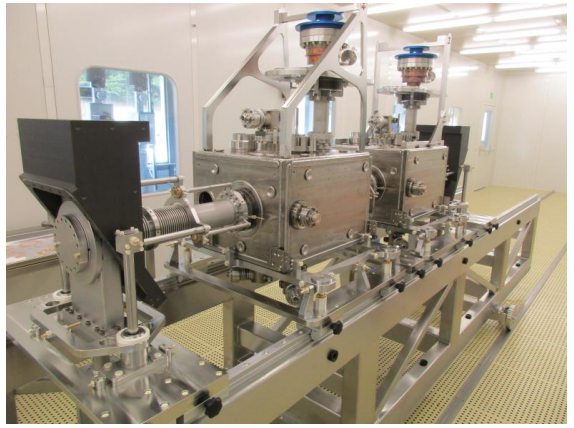
- Extrapolate to the next Crab-cavities
  - Extrapolate to the RFD prototype
  - Extrapolate to the 10 Crab-cavities assembled through in kind contribution (from UK and Canada)

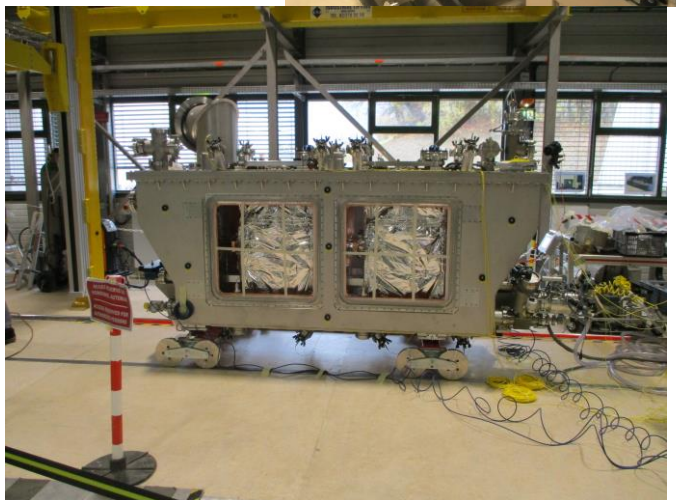
Workflow (Assembly of the Crab-cavities)

- 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



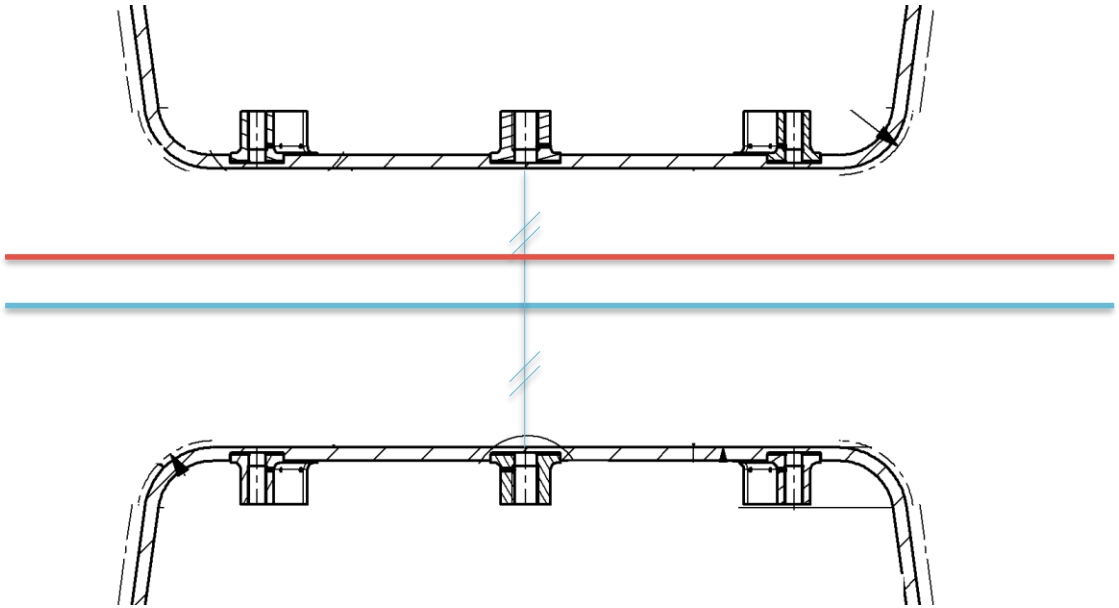






Workflow (Assembly of the Crab-cavities)

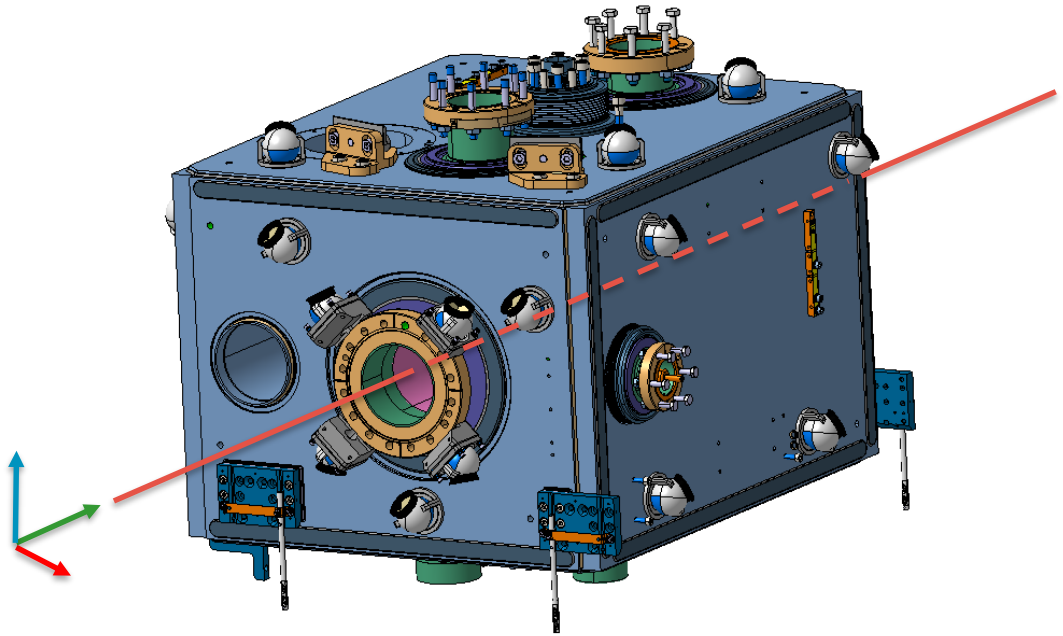
- **Determination of the mechanical axis → Capacitive plate of the cavities**
- Fiducialisation of the Dressed Cavities
- String line assembly in clean room
- Installation of the others components on the string line
- Final alignment of the string line
- Installation of the top plate (supporting plate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

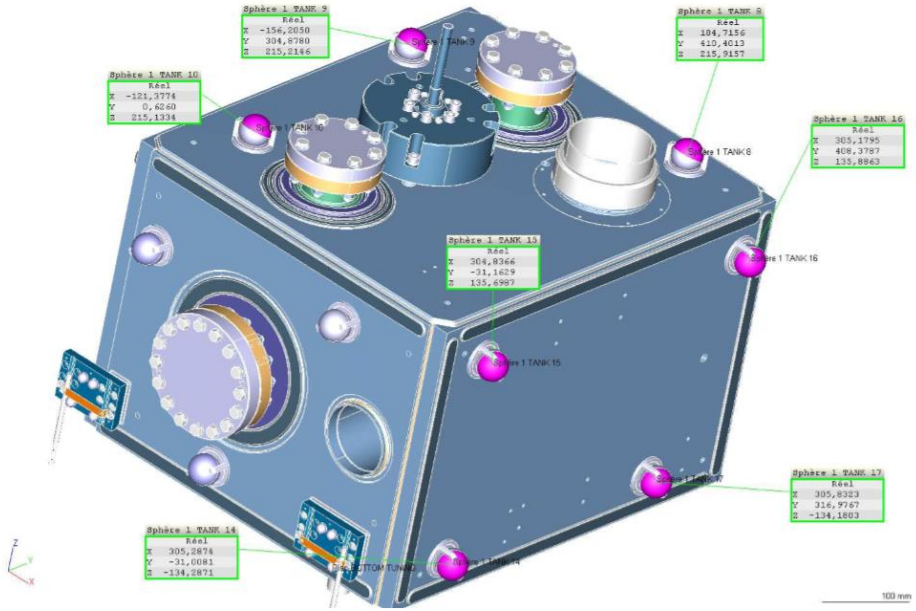


Metrology step	Cavity 1	Cavity 2
Before treatment	-0.691	-0.291
After treatment	-0.673	No metrology
After tunning	-0.661	-0.165
Capacitive plate : Pins check	-0.553	No metrology
After tank welding	**-0.557**	**-0.040**

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





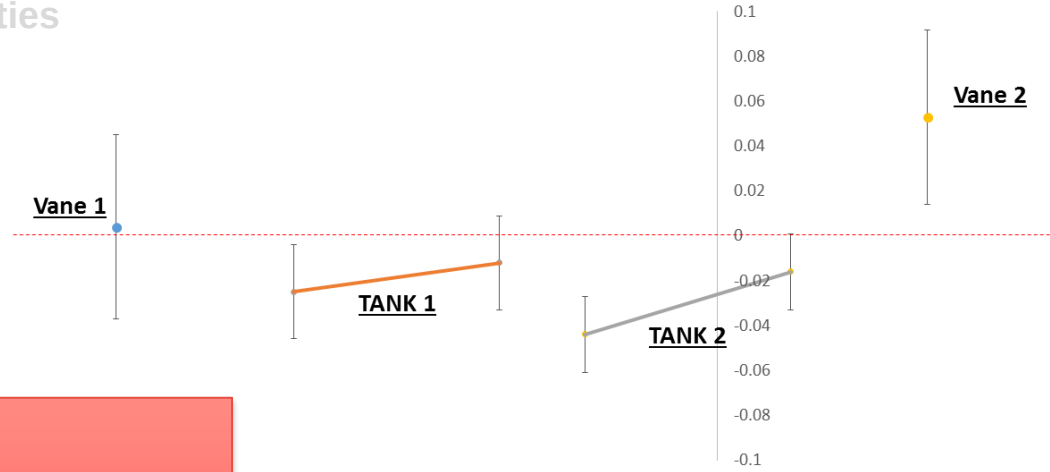
3D measurement of :

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

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

Vertical displacement between :
Without vacuum and under vacuum

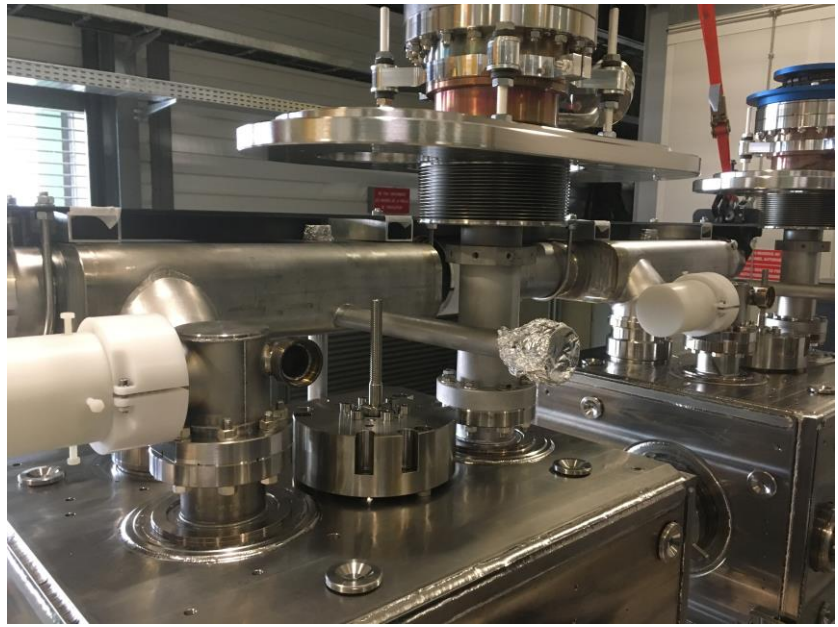


Objective / Results :

- 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

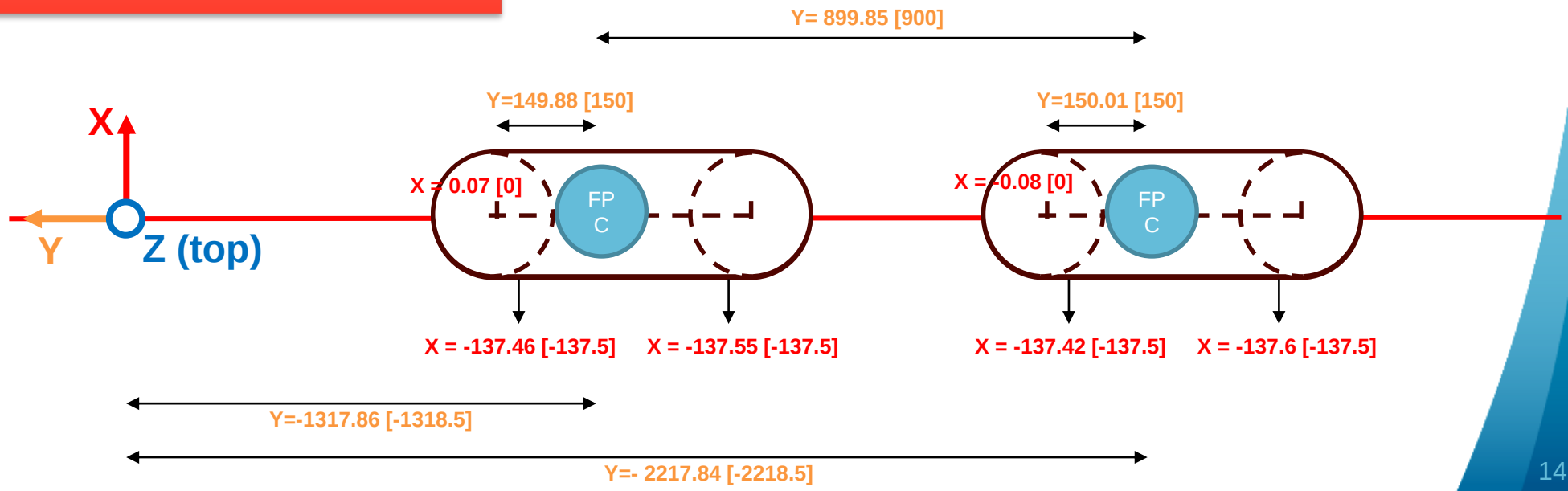
Workflow (Assembly of the Crab-cavities)

- 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



Objective / Results :

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



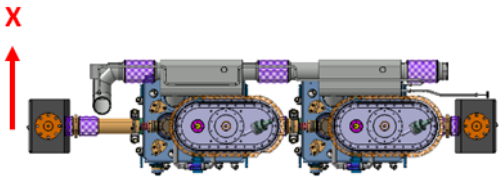
Workflow (Assembly of the Crab-cavities)

- 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

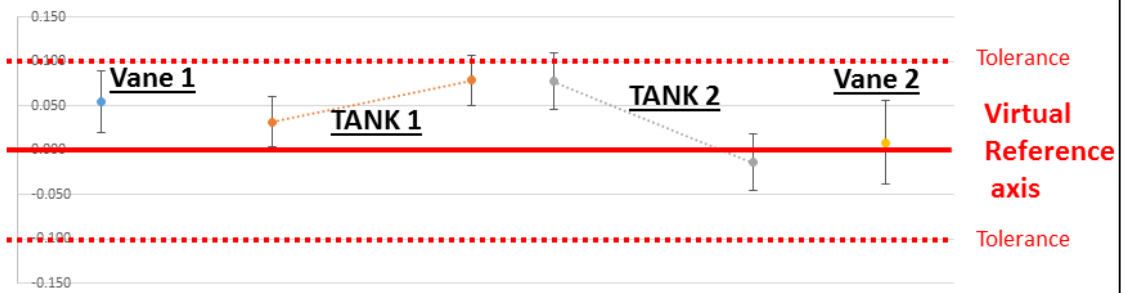
Objective / Results :
- Alignment : < 0.1 mm

Absolute precision

TOP VIEW

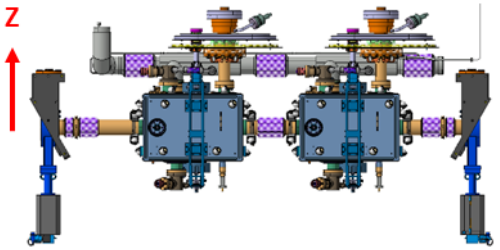


Radial alignment (relative to virtual reference axis defined by the trolley's fiducials)

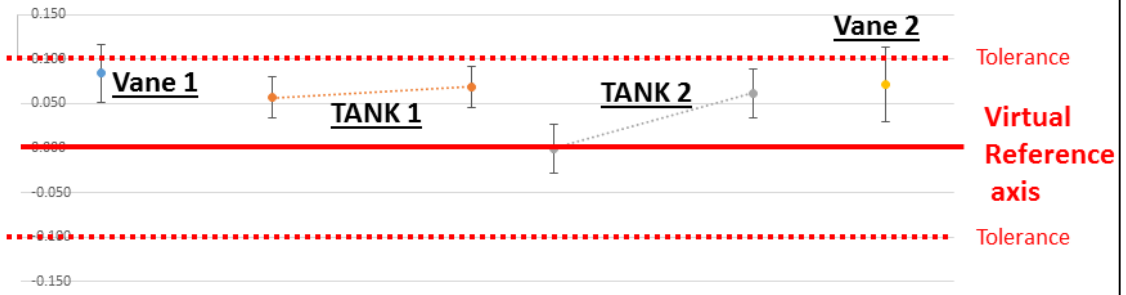


Absolute precision

SIDE VIEW



Vertical alignment (relative to virtual reference axis defined by the trolley's fiducials)



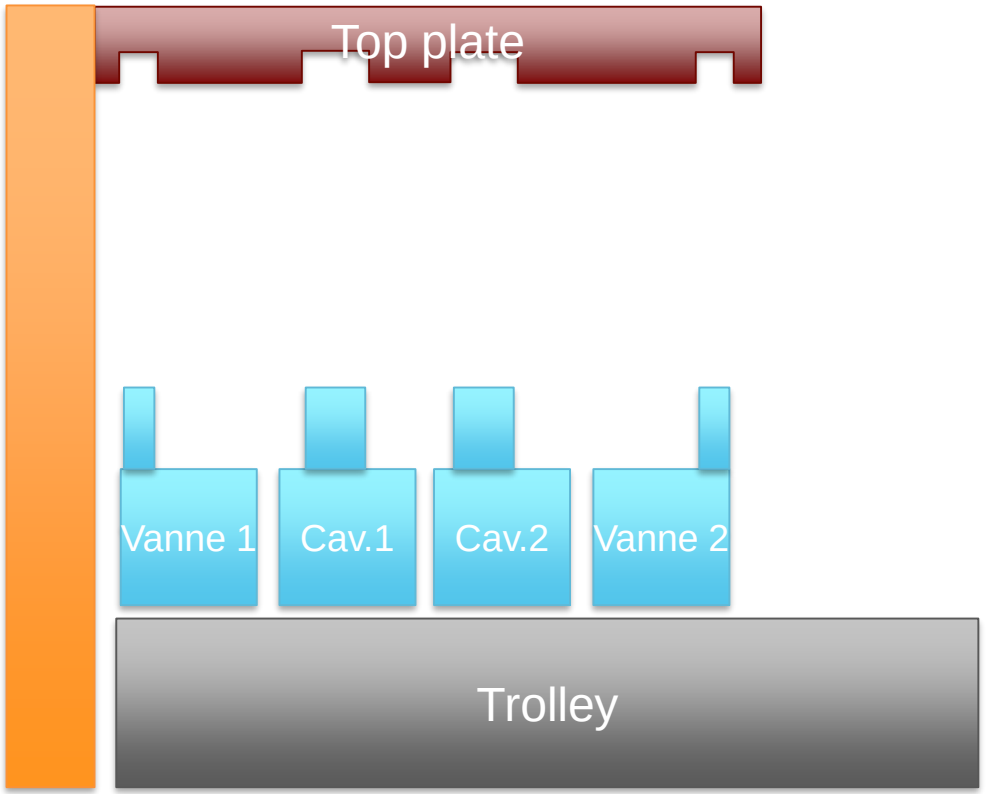
Workflow (Assembly of the Crab-cavities)

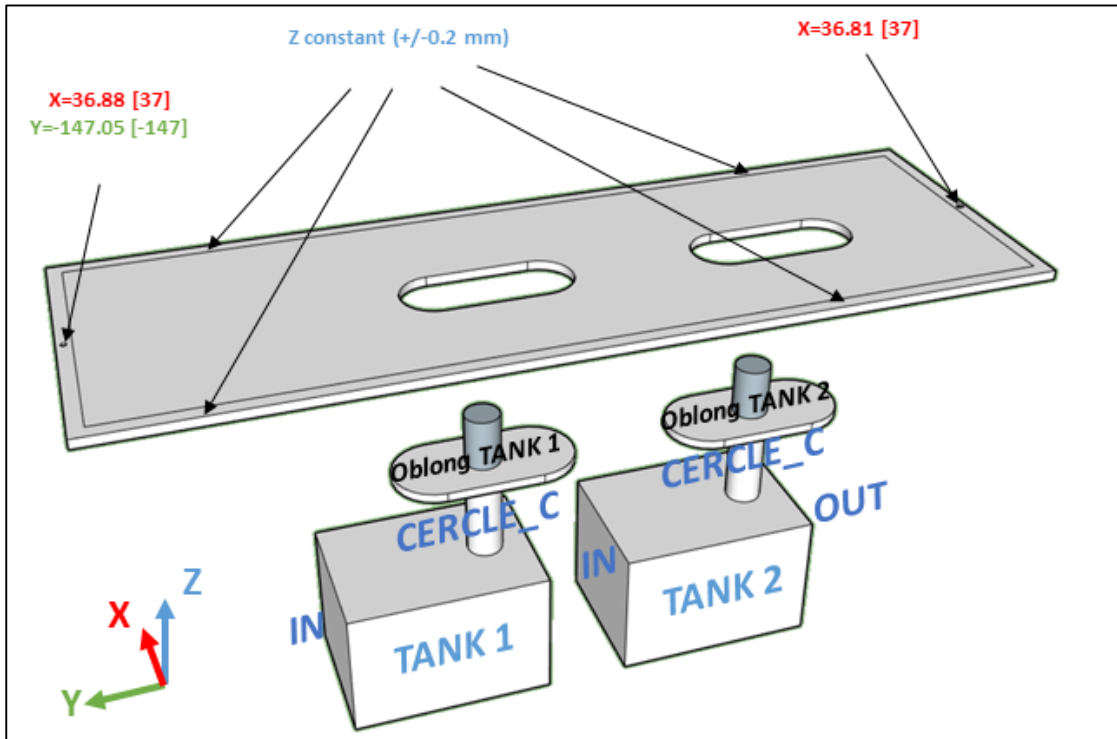
- Determination of the mechanical axis → Capacitive plate of the cavities
- Fiducialisation of the Dressed Cavities
- String line assembly in clean room
- Installation of the others components on the string line
- Final alignment of the string line
- **Installation of the top plate (supporting plate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

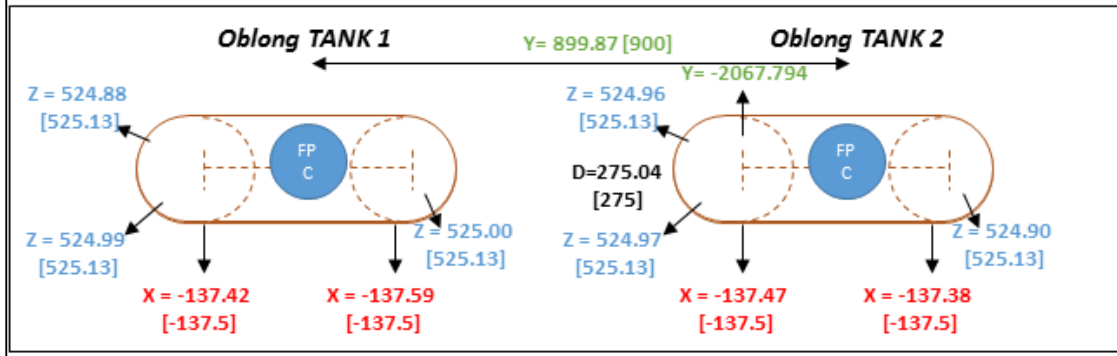
Objective / Results :

- 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

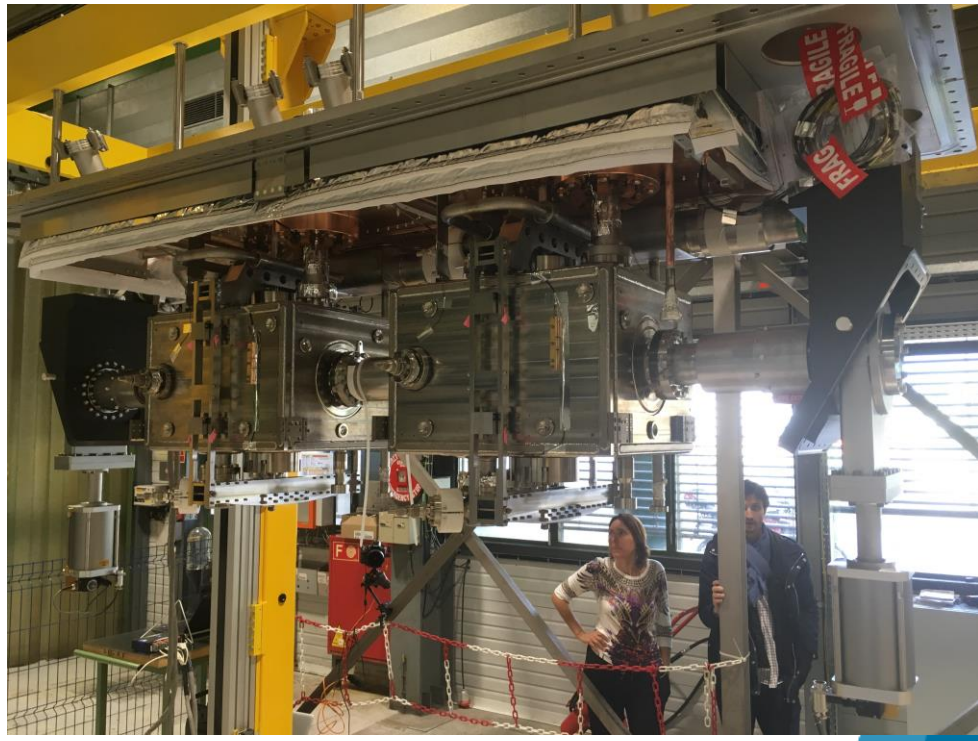






Workflow (Assembly of the Crab-cavities)

- 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



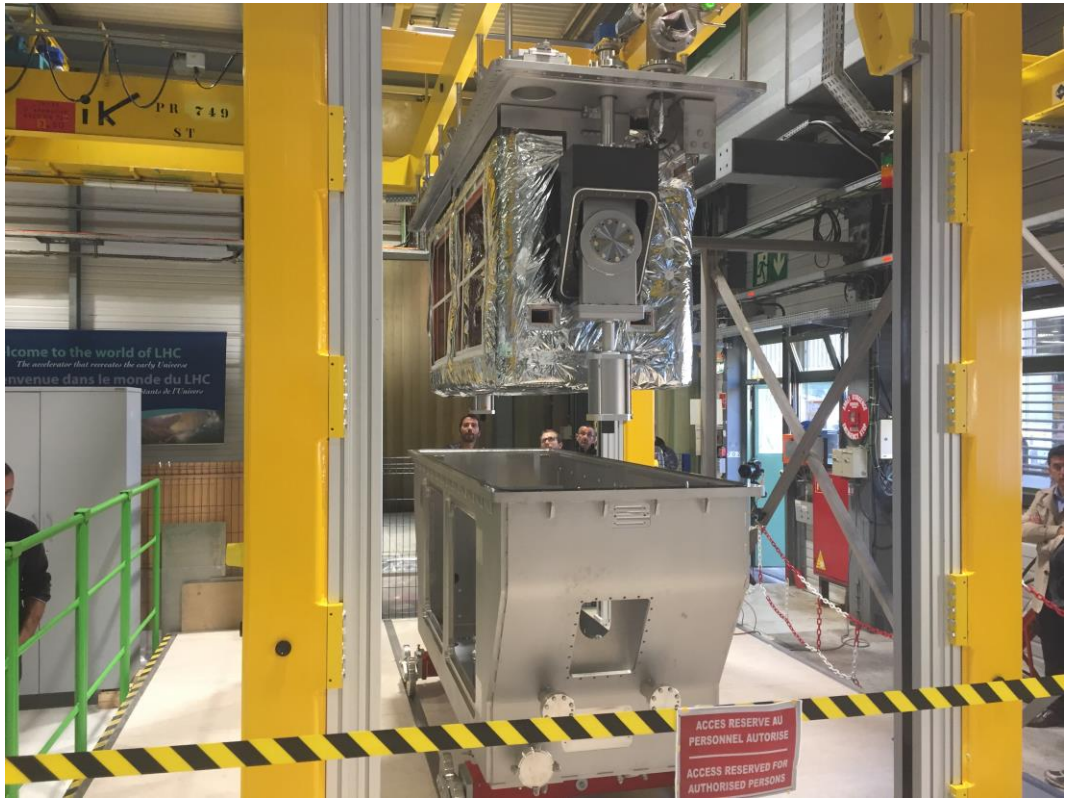
Workflow (Assembly of the Crab-cavities)

- 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**

Objective / Results :

- Installation of the cryomodule: at 0.2 mm

→ Taking into account the trajectory of the gantry crane



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
  - Installation of the DQW prototype in SPS tunnel

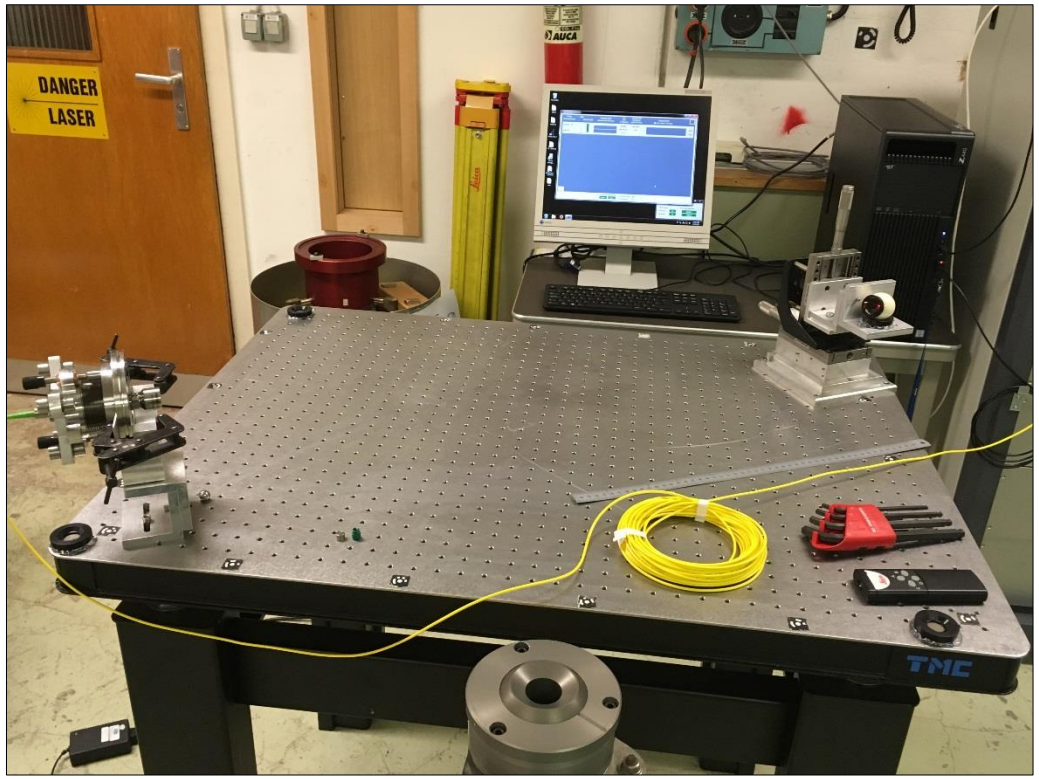
- Extrapolate to the next Crab-cavities
  - Extrapolate to the RFD prototype
  - Extrapolate to the 10 Crab-cavities assembled through in kind contribution (from UK and Canada)

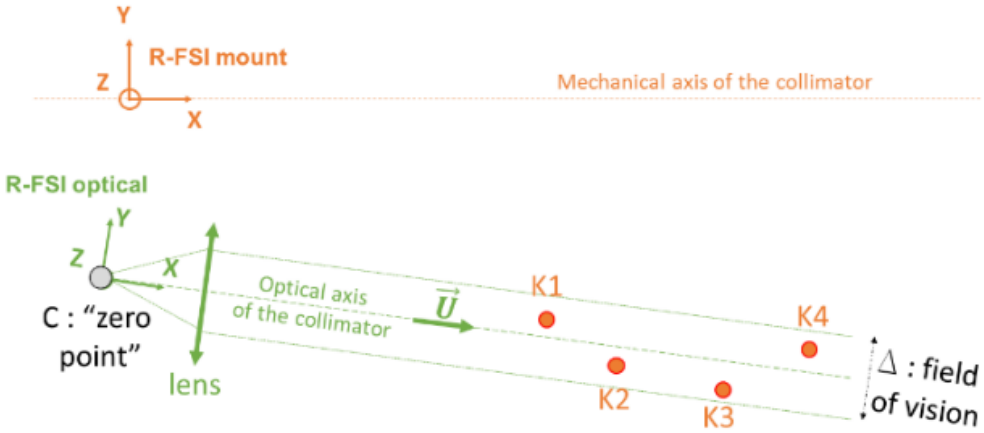
Installation of FSI system

- **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

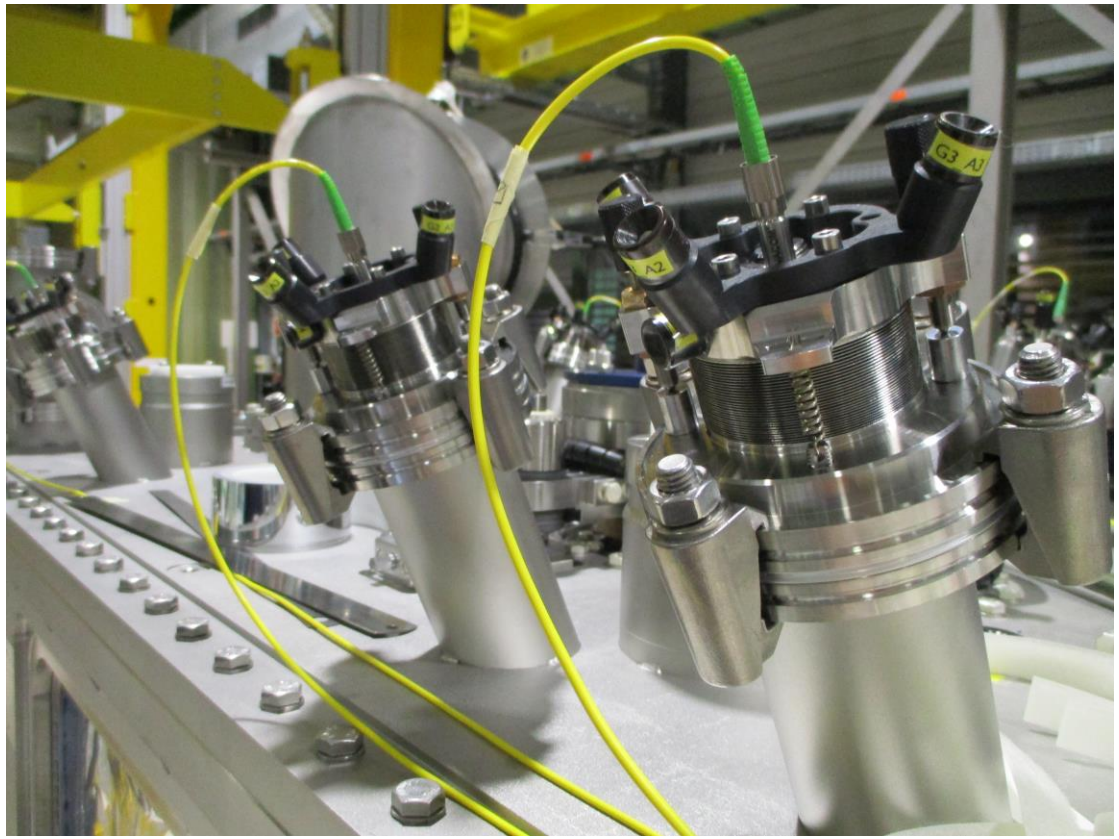
$$\begin{pmatrix} X_{K_i} \\ Y_{K_i} \\ Z_{K_i} \end{pmatrix} = \begin{pmatrix} X_C \\ Y_C \\ Z_C \end{pmatrix} + \begin{pmatrix} U_X \\ U_Y \\ U_Z \end{pmatrix} * Dist_i$$

Installation of FSI system

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

Objective / Results :

- Accuracy : < 0.02 mm



3D measurement of :

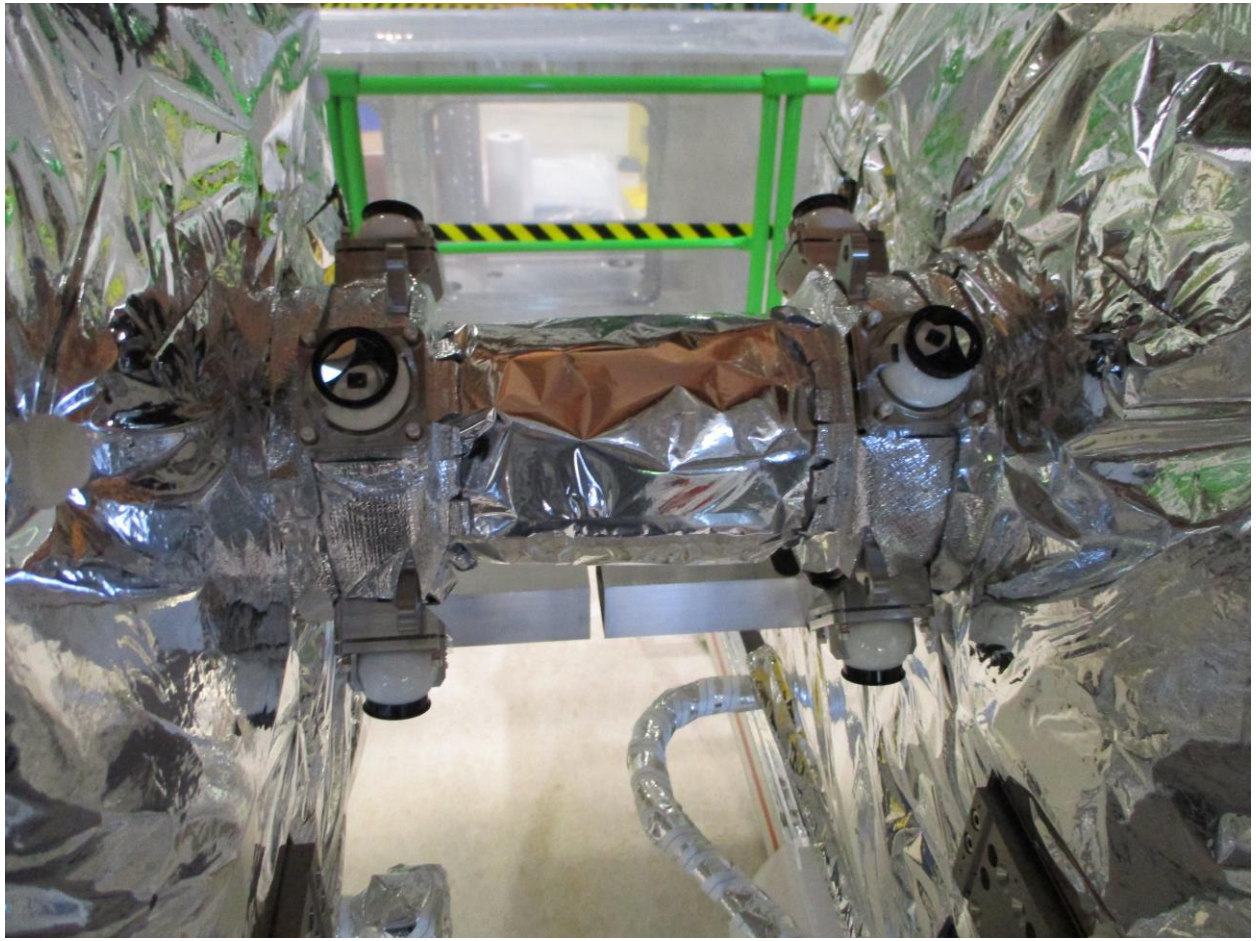
- Cryomodule
- FSI feedtrough

Installation of FSI system

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

Objective / Results :

- Accuracy : < 0.02 mm



3D measurement of :

- Dressed cavities
- FSI targets

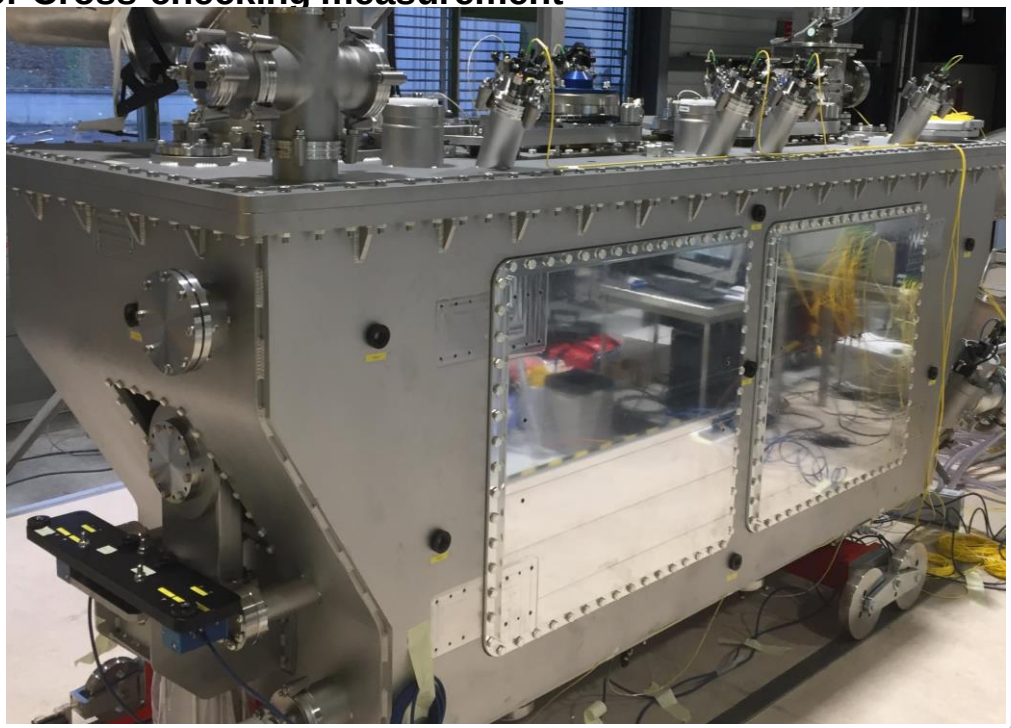
Outline

- **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**
  - 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)

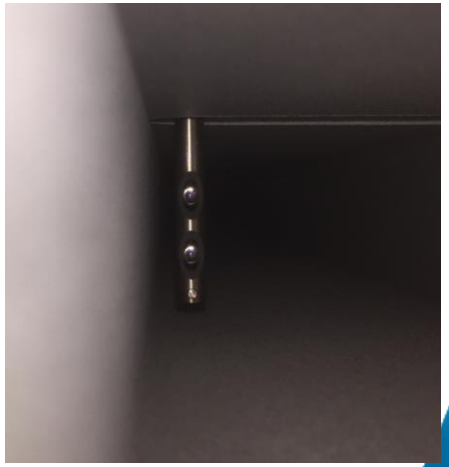
Validation at warm and cold conditions

- **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 :

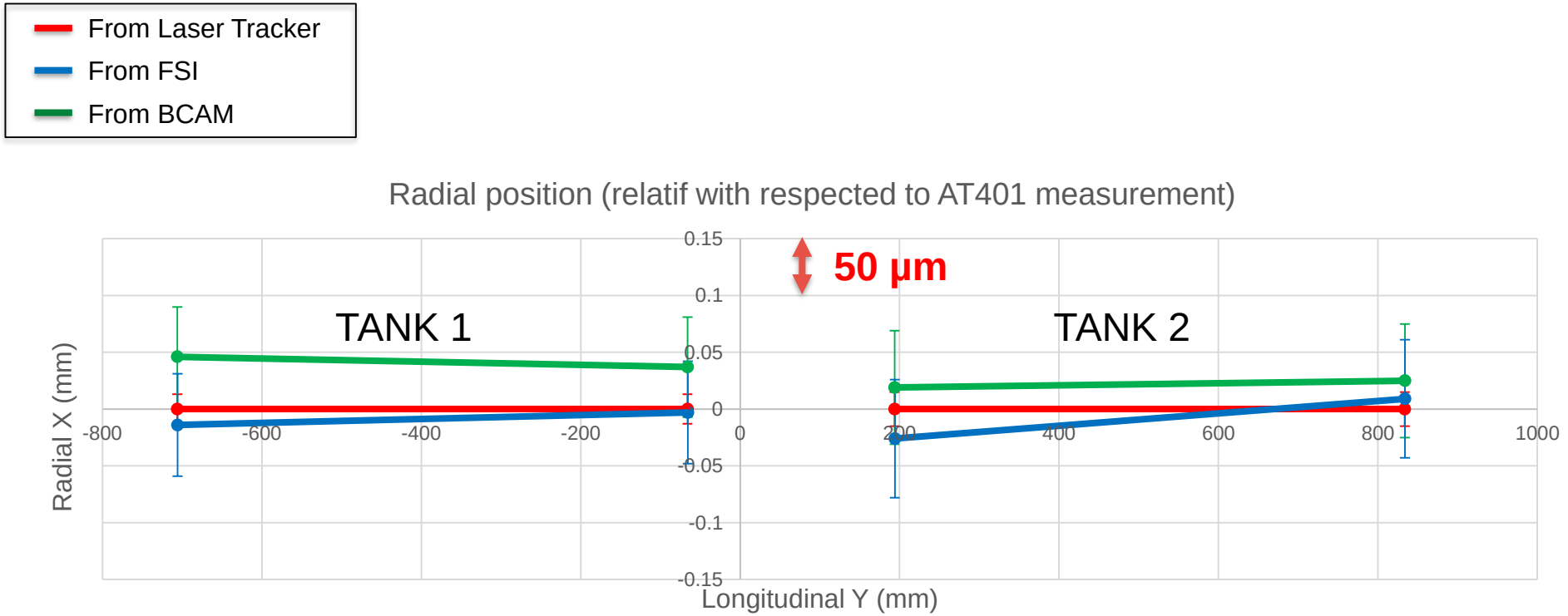
- 3D measurement of the supporting plate for the BCAM : < 0.02 mm
- Installation of the supporting plate on the cryomodule : < 0.02 mm
- Installation of BCAM targets
- Installation of BCAM window

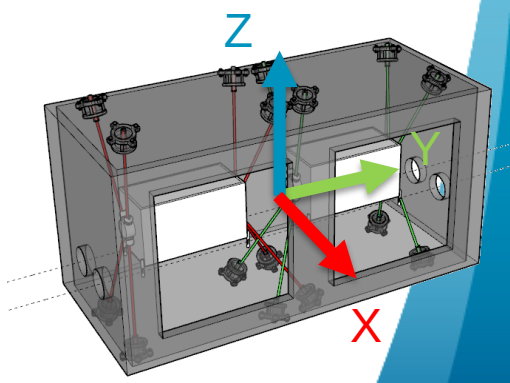


Validation at warm and cold conditions

- 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 :
- Intercomparison : < 0.05 mm



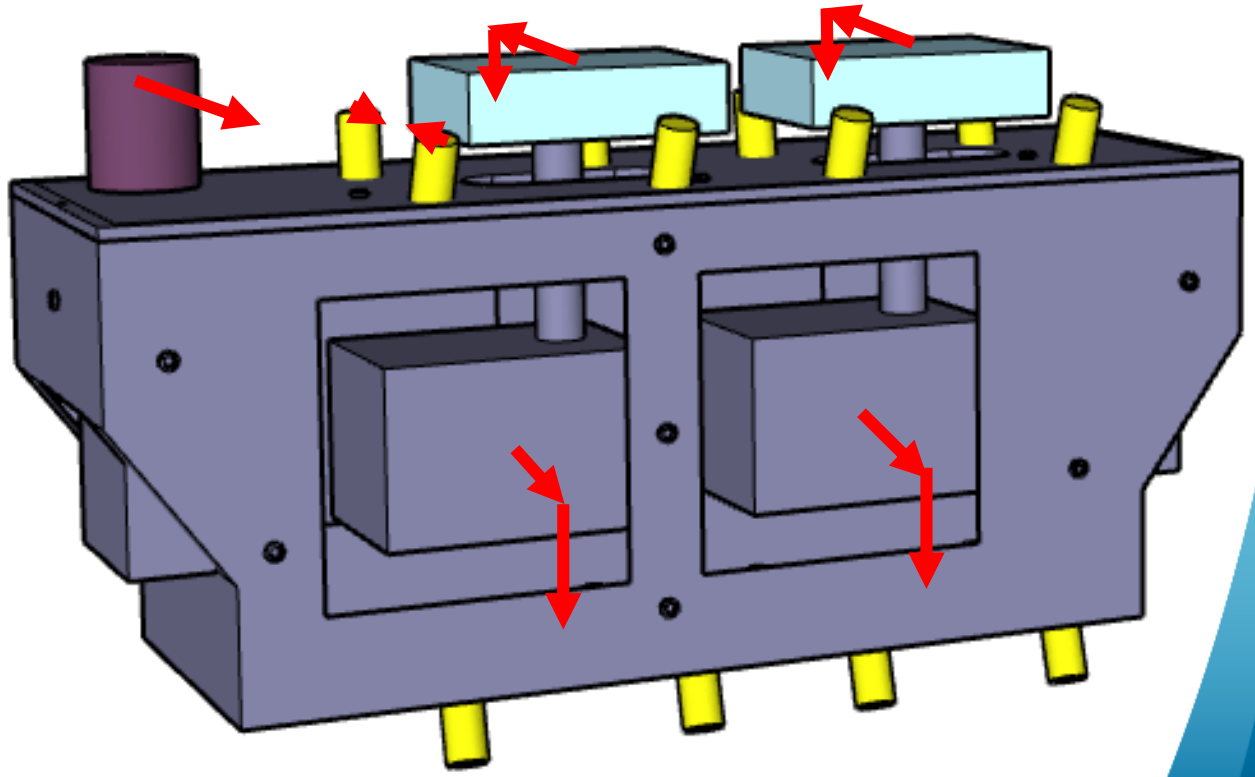


Validation at warm and cold conditions

- 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

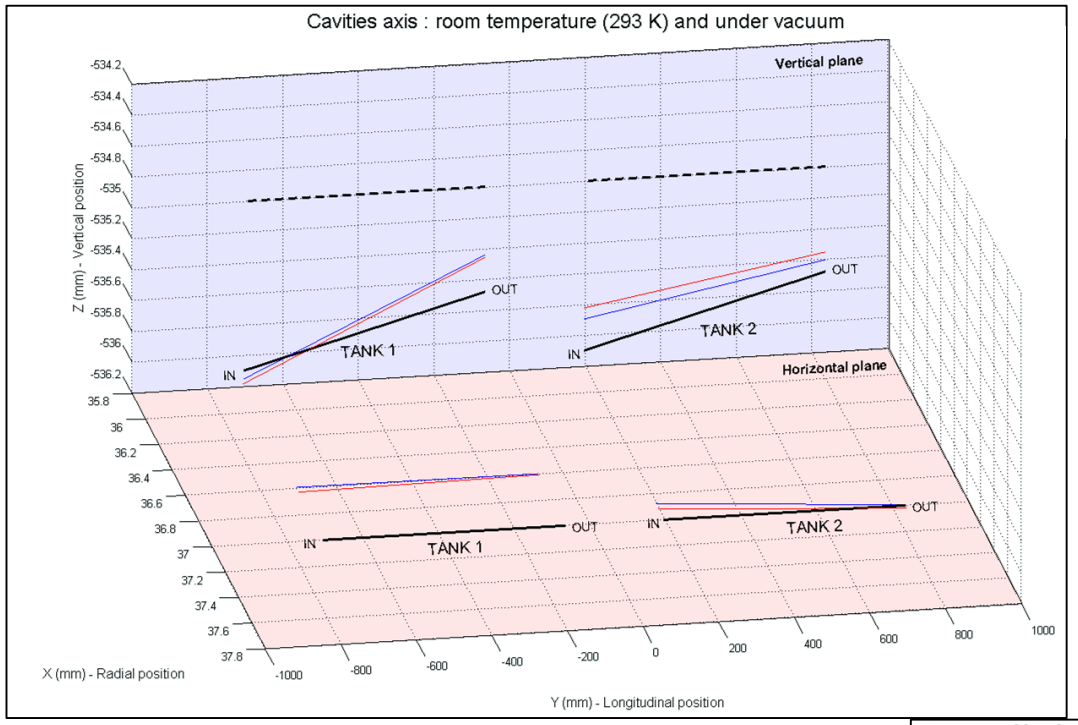


Validation at warm and cold conditions

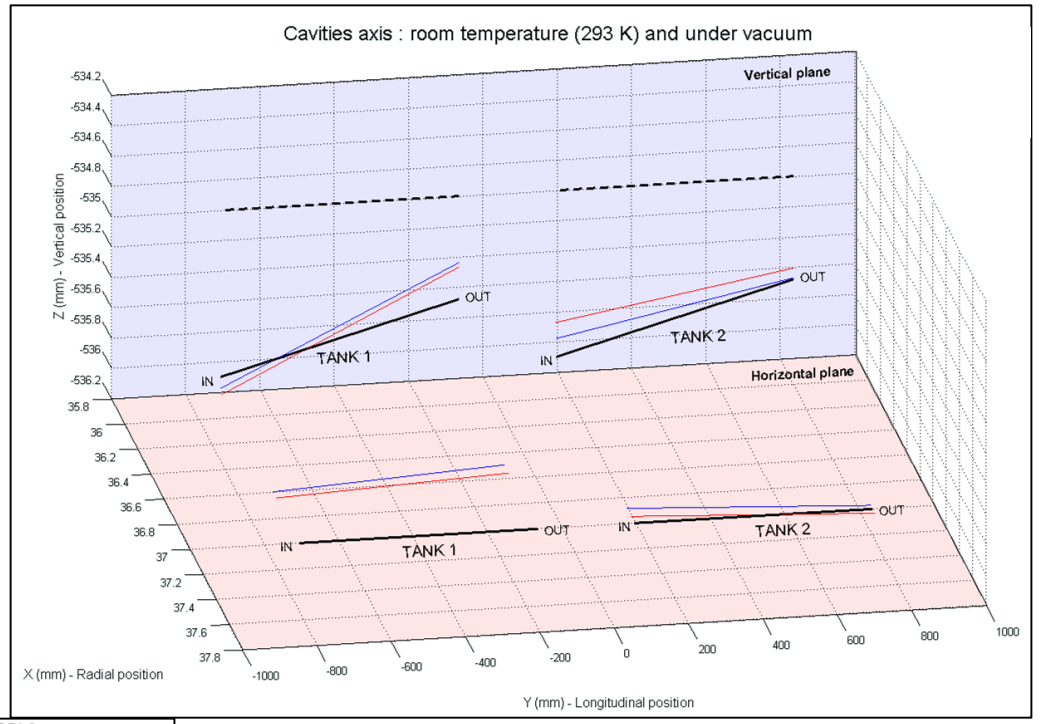
- Installation of an alternative monitoring system (BCAM system)
- Validation at warm
- Impact of vacuum on the string line
- **Impact of transport on the string line**
- Validation at cold condition

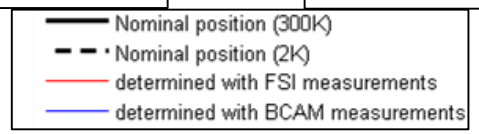
Objective / Results :
- Impact of transport : < 0.05 mm

BEFORE TRANSPORT



AFTER TRANSPORT

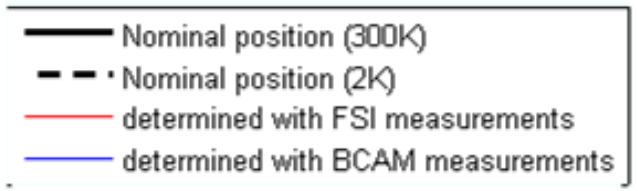


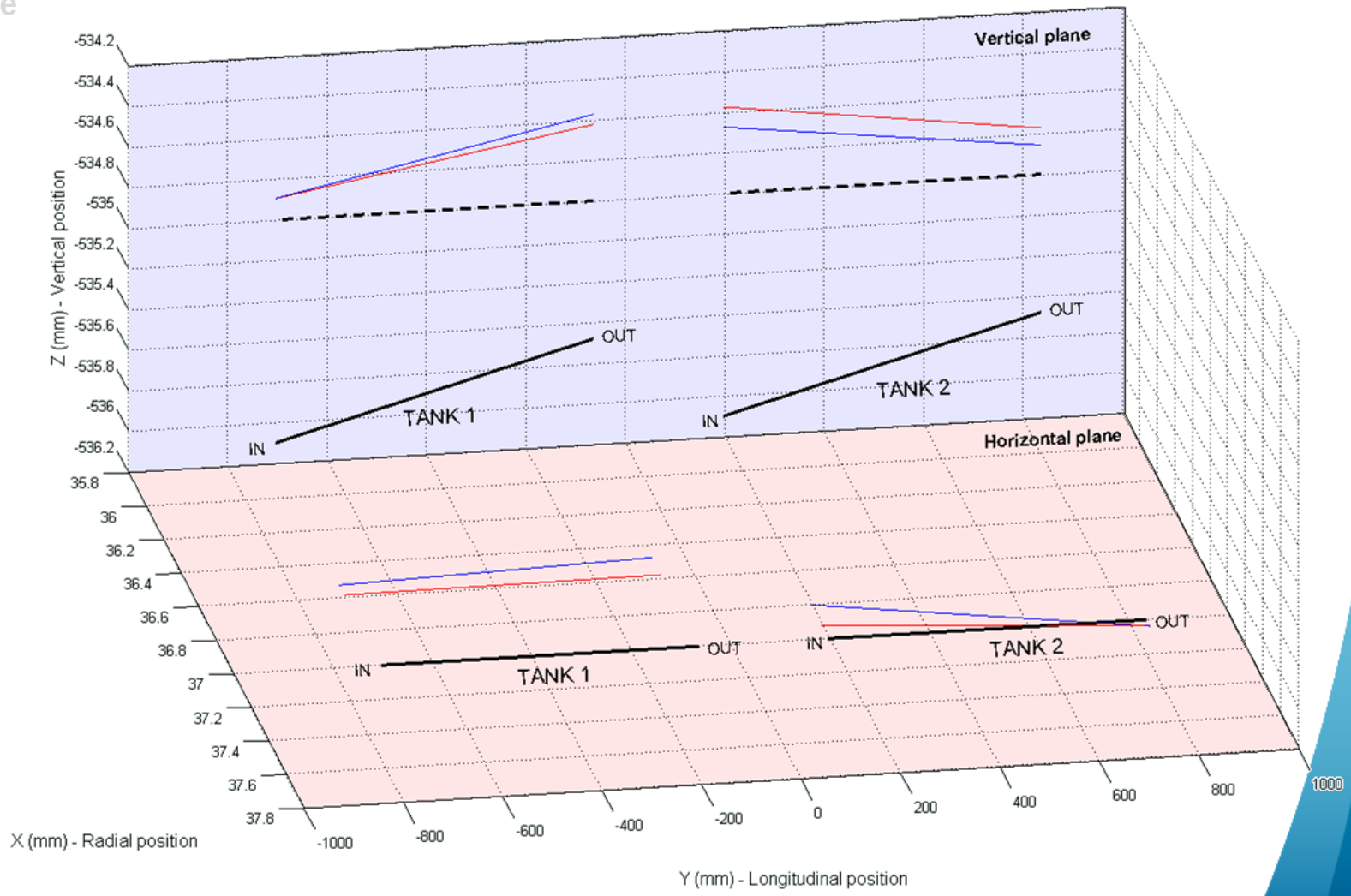


Validation at warm and cold conditions

- 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





Outline

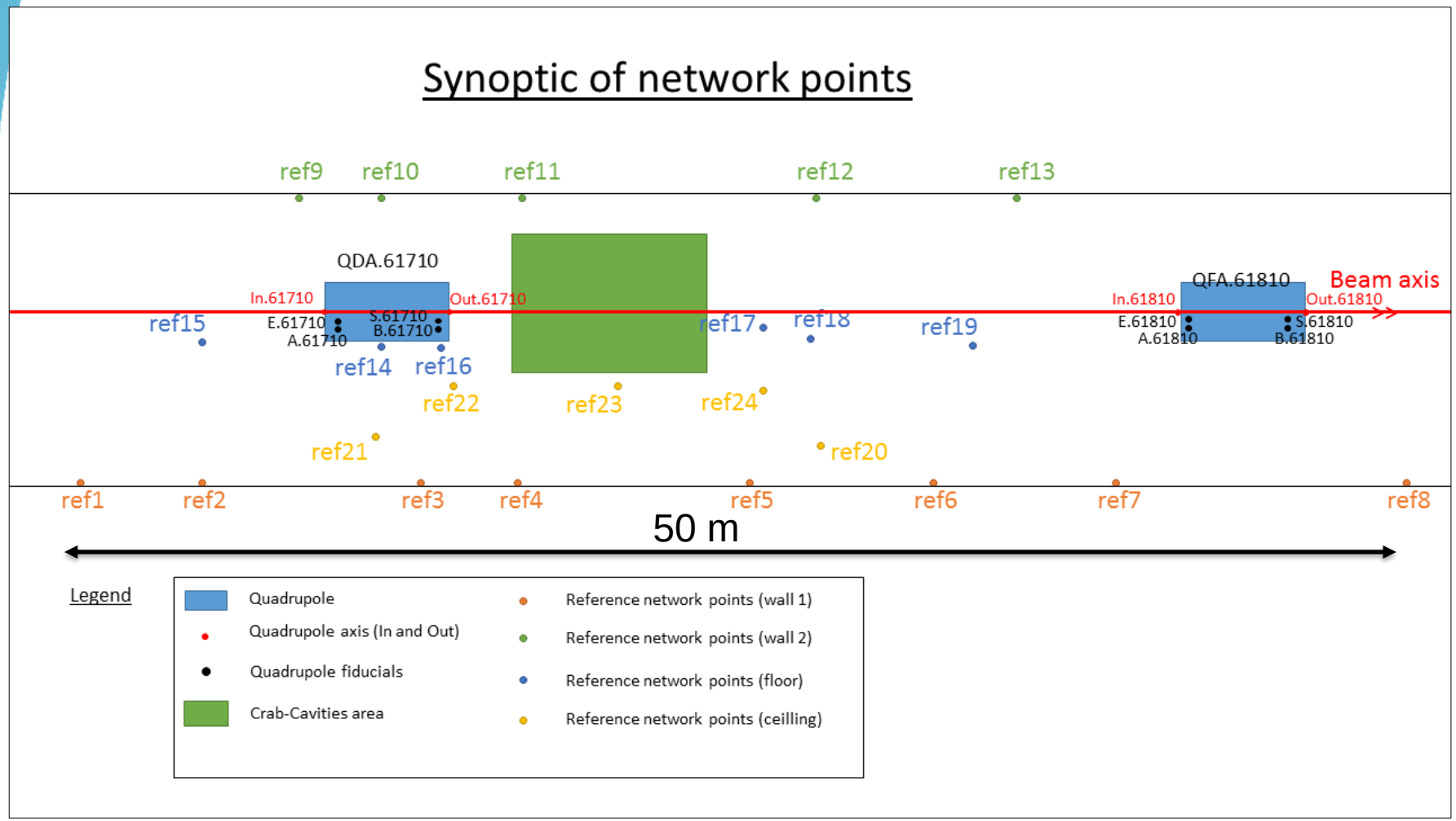
- **Assembly measurements of the DQW prototype**
  - Measurement on the associated infrastructures
  - Workflow (Assembly of the Crab-cavities)
  - Installation of FSI system
  - Validation at warm and cold conditions
  - **Installation of the DQW prototype in SPS tunnel**

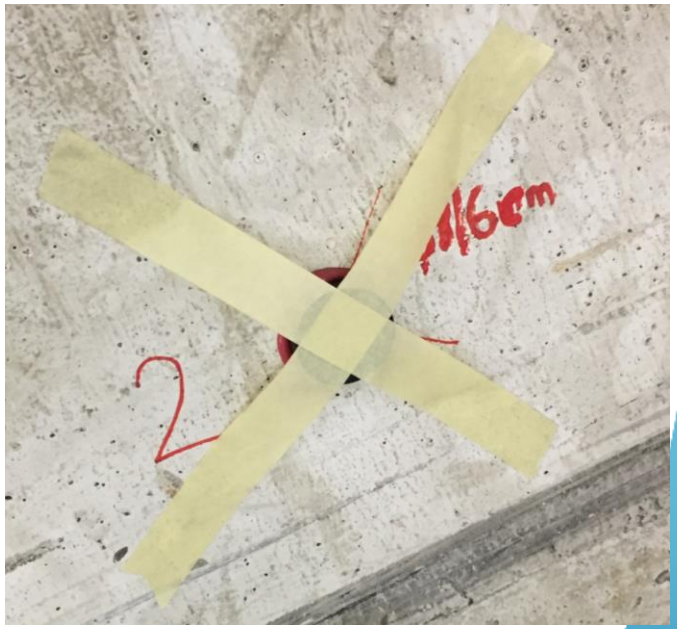
- Extrapolate to the next Crab-cavities
  - Extrapolate to the RFD prototype
  - Extrapolate to the 10 Crab-cavities assembled through in kind contribution (from UK and Canada)

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 folow up (using FSI measurement)

Objective / Results :
- Accuracy : < 0.15 mm

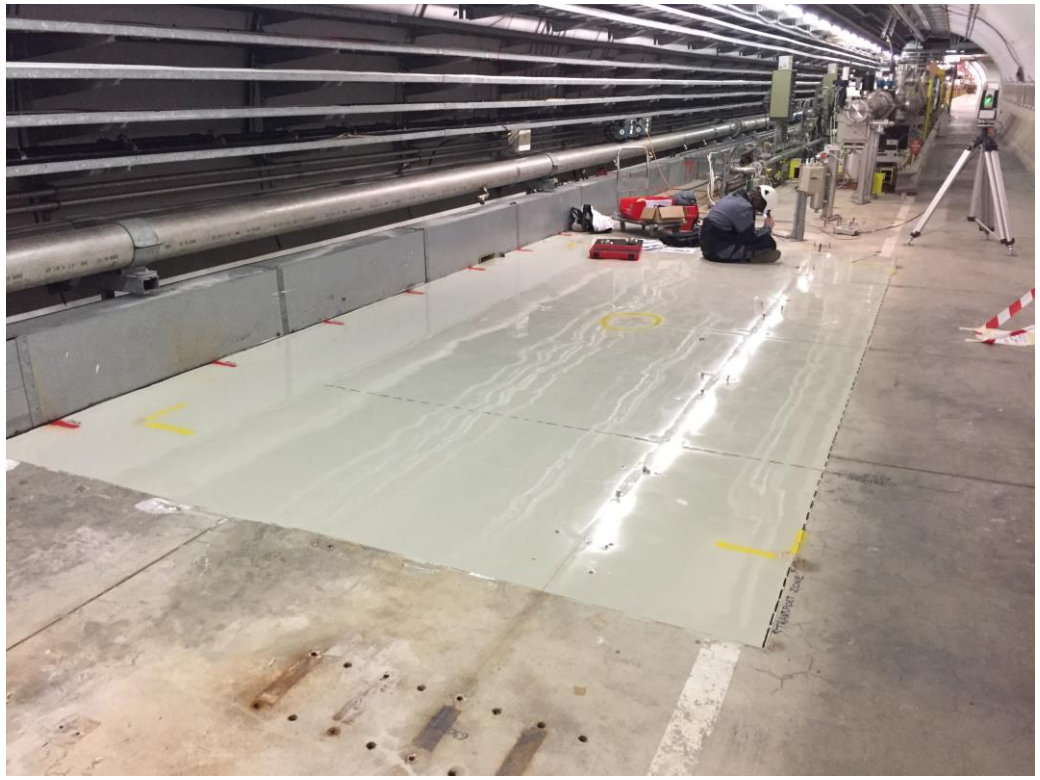




Installation of the DQW prototype in SPS tunnel

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

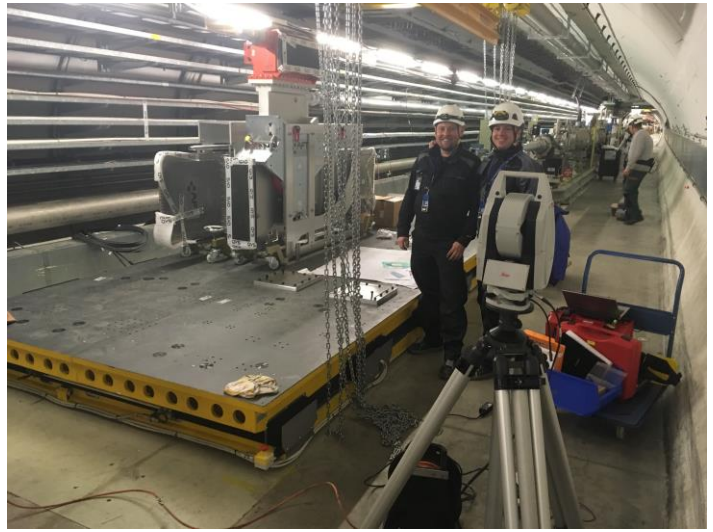
Objective / Results :
- Accuracy : few mm

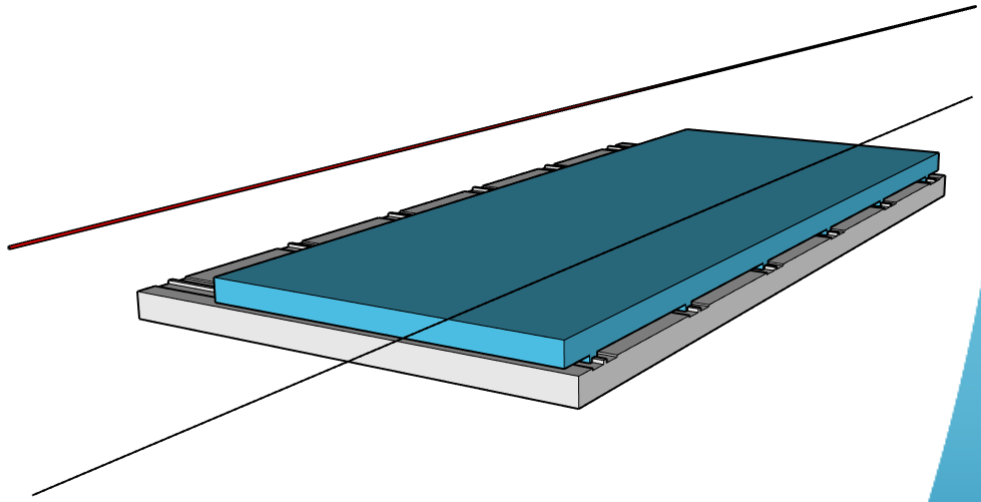


Installation of the DQW prototype in SPS tunnel

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

Objective / Results :
- Installation of SPS tunnel table : few mm



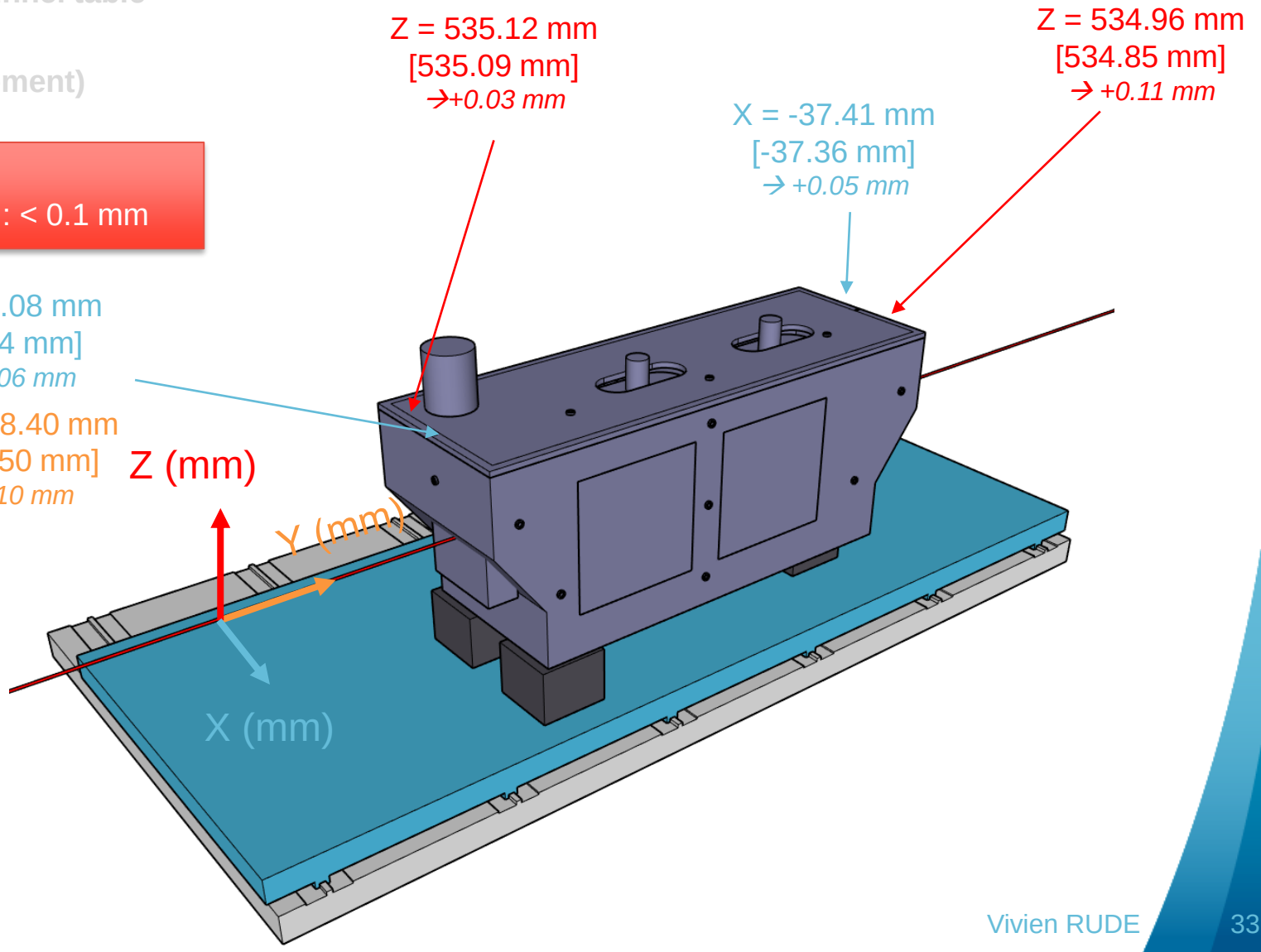


Installation of the DQW prototype in SPS tunnel

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

Objective / Results :

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

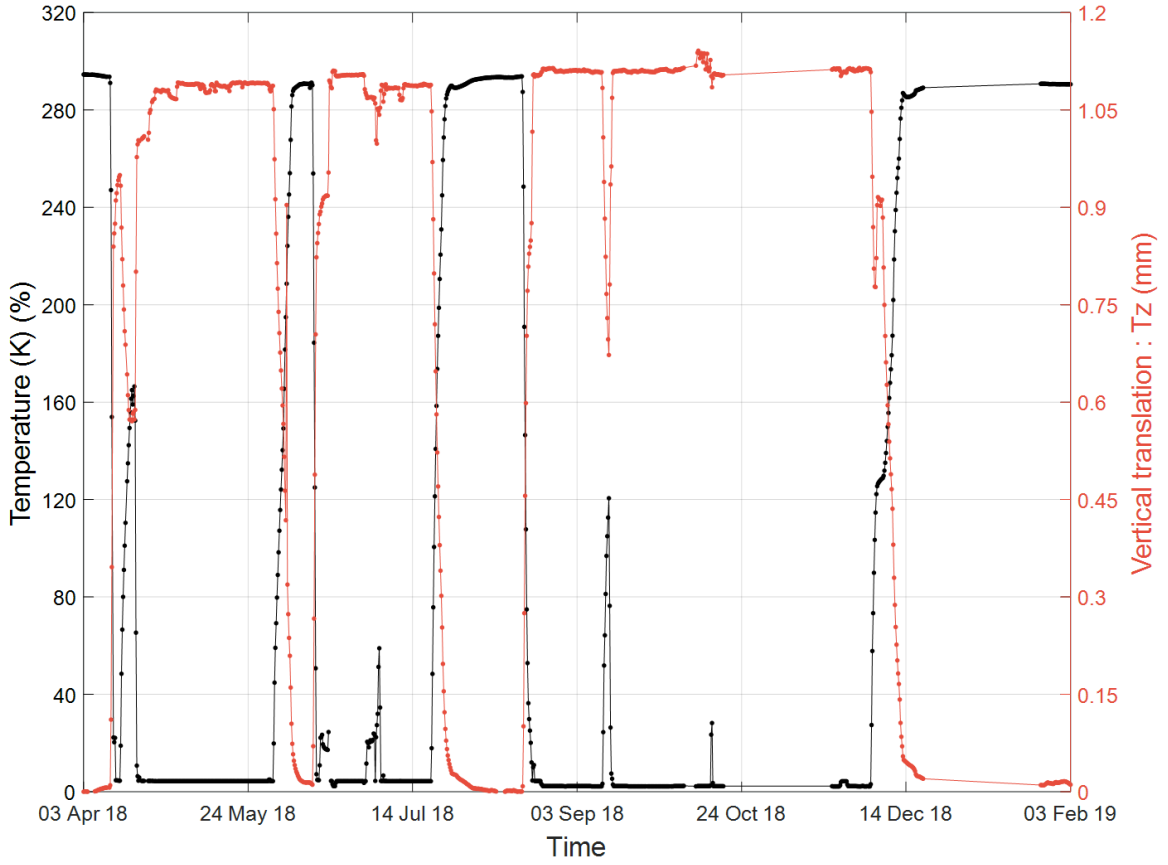


Installation of the DQW prototype in SPS tunnel

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

Objective / Results :

- Repeatability: < 0.02 mm



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
  - 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)**

- **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 forseen**
- **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