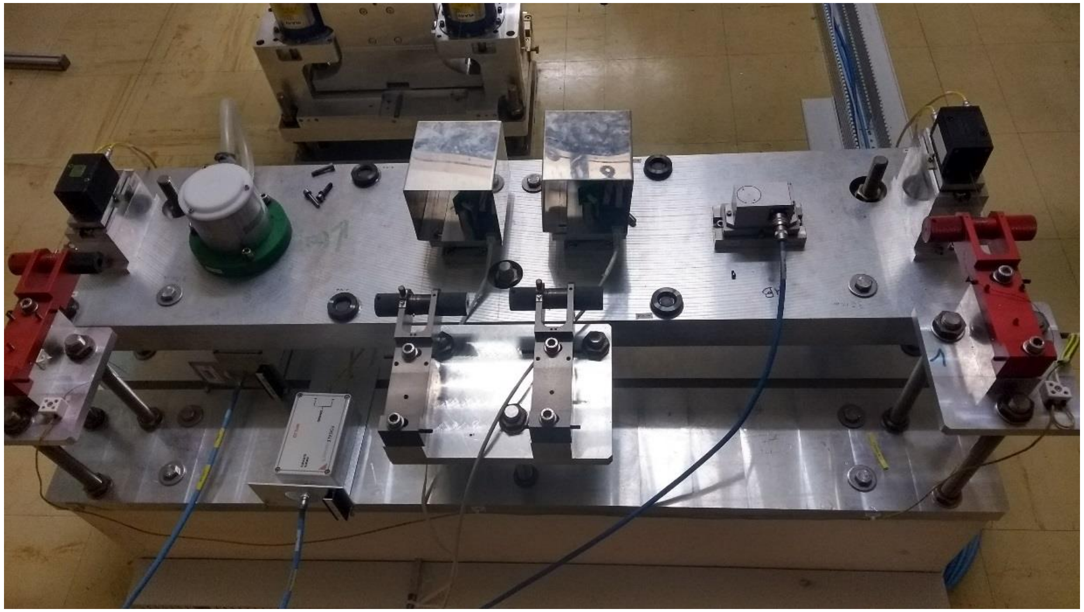
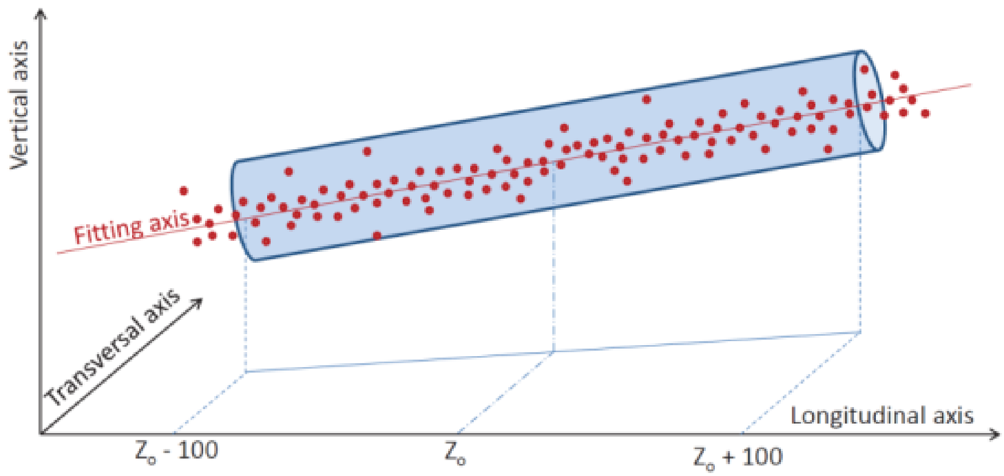
Active repositioning and sensor characterization for the CLIC module



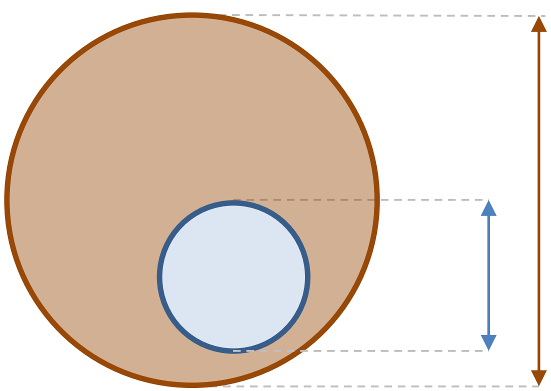
Anna Zemanek EN-ACE-SU

1. CLIC has stringent alignment requirements



<u>Requirement :</u>

- Pre-Alignment : ±14 μm along a 200 m sliding window



70 μm – an ‘average’ human hair

28 μm – CLIC’s requirement over 200 m

2. Sensors for the CLIC module

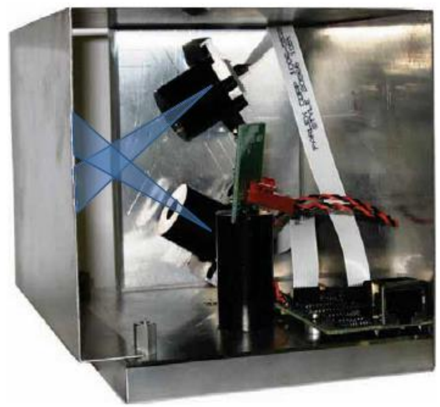
Radial & vertical offsets to a stretched wire

Range 10 mm

Precision 1 µm

Installed on an interface of 3 spheres

Wire Positioning Sensor



Optical WPS

Vectran-Silver wire

2 CCD cameras

Calibration of cameras provided by Brandeis University (OSI)

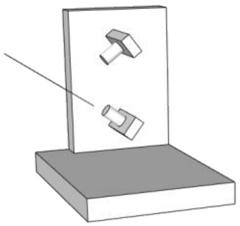
Capacitive WPS

Carbon PEEK / Carbon PES wires

4 electrodes (2 per axis)

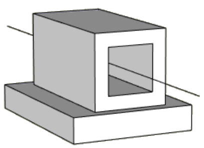
Linear and absolute calibration is required

2. Sensors for the CLIC module



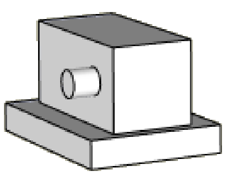
oWPS:

- Precision : 1 µm
- Accuracy : 10 µm
- Maximum 500 Gy



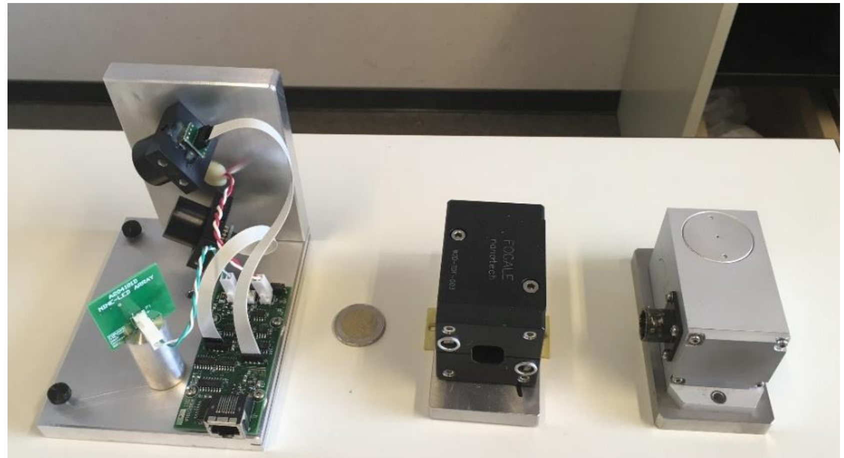
cWPS :

- Precision : 1 µm
- Accuracy : 5 µm
- Rad-Hard (5 MGy)

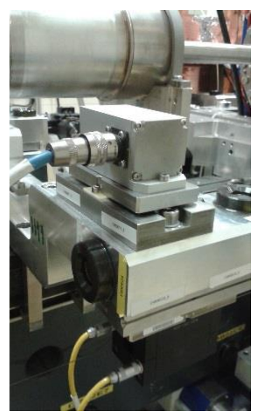


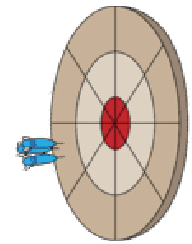
Tilt meter :

- Precision : 3 µrad
- Accuracy (1) : 60 µrad
- Accuracy (2) : 10 µrad
- Not Rad-Hard



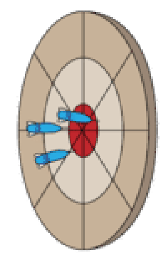
oWPS cWPS Tilt meter





low accuracy

high precision



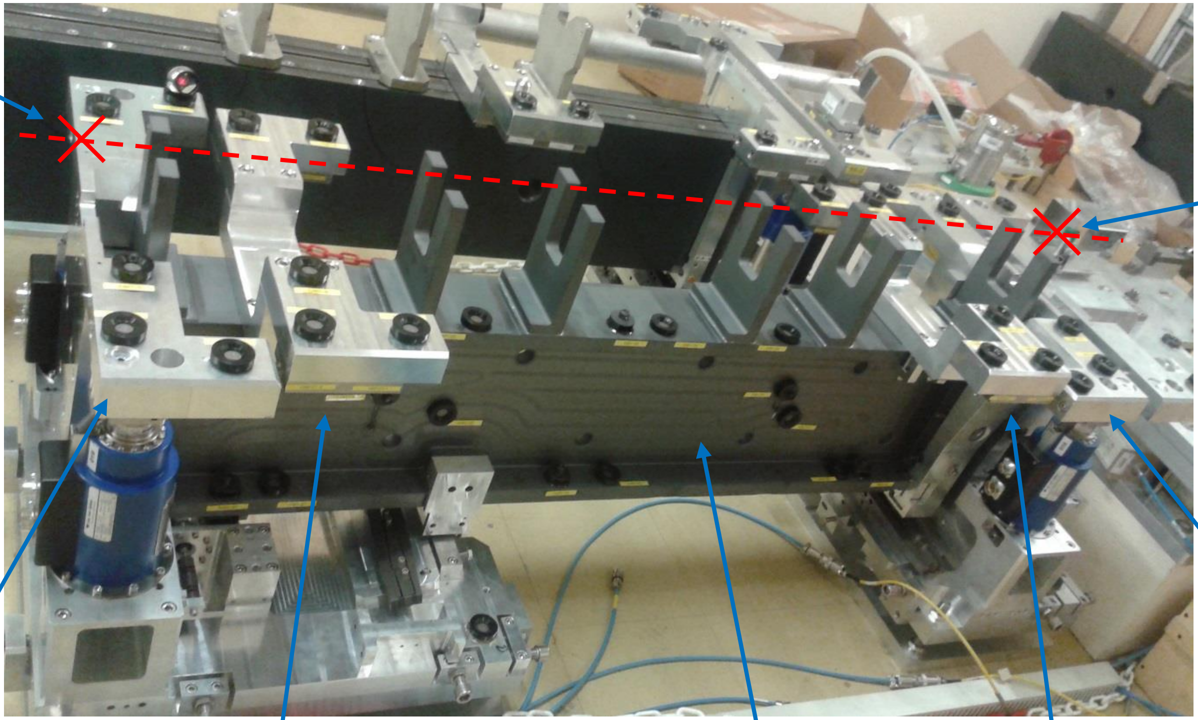
high accuracy

low precision

3. Estimated precision

IN

main axis



OUT

'old'
cradle

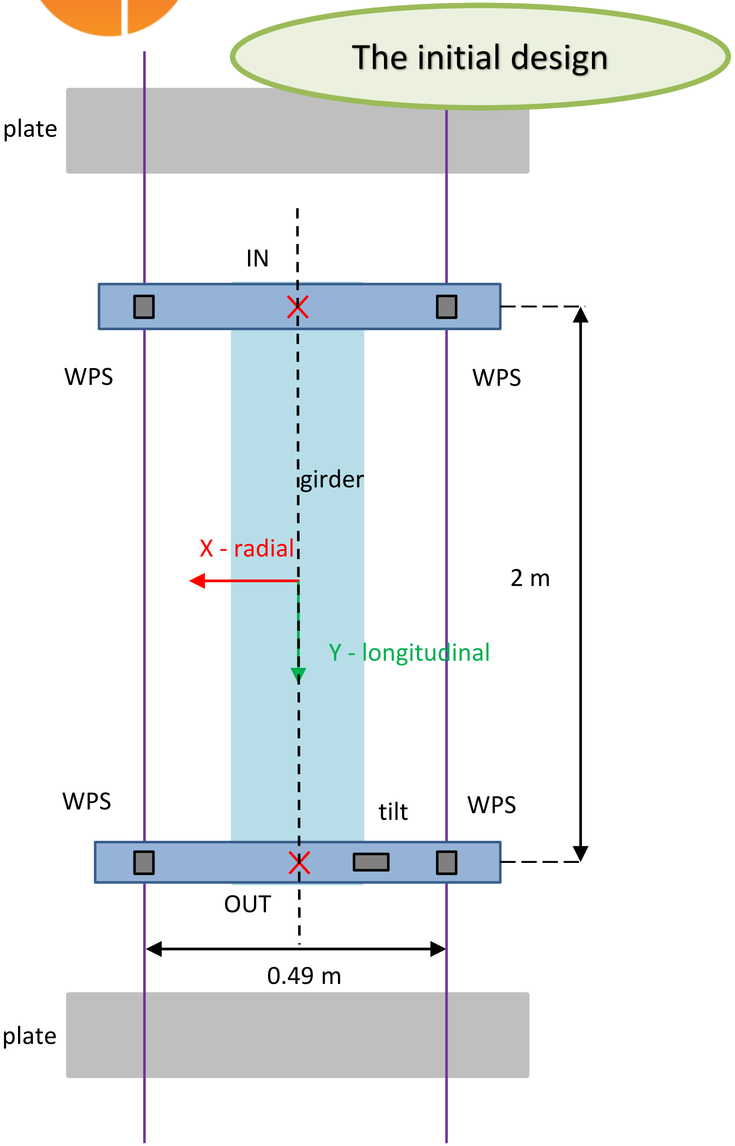
'old'
cradle

'new'
WPS arm

girder

'new'
WPS arm

3. Estimated precision



Simulations:

- Length of the girder 2 m
- Coordinate frame in the middle of the girder
- Sensors located 20 cm lower than the main axis
- 0.49 m between sensors in the radial direction
- Longitudinal distance between sensors 2 m

Precision

2 wires:

1. both with an accuracy of 5 µm (cWPS)

X [µm]	Z [µm]
10	7

X – radial, Z – vertical

2. the first with an accuracy of 5 µm (cWPS), the second with 10 µm (oWPS)

X [µm]	Z [µm]
13	8

1 wire (with cWPS):

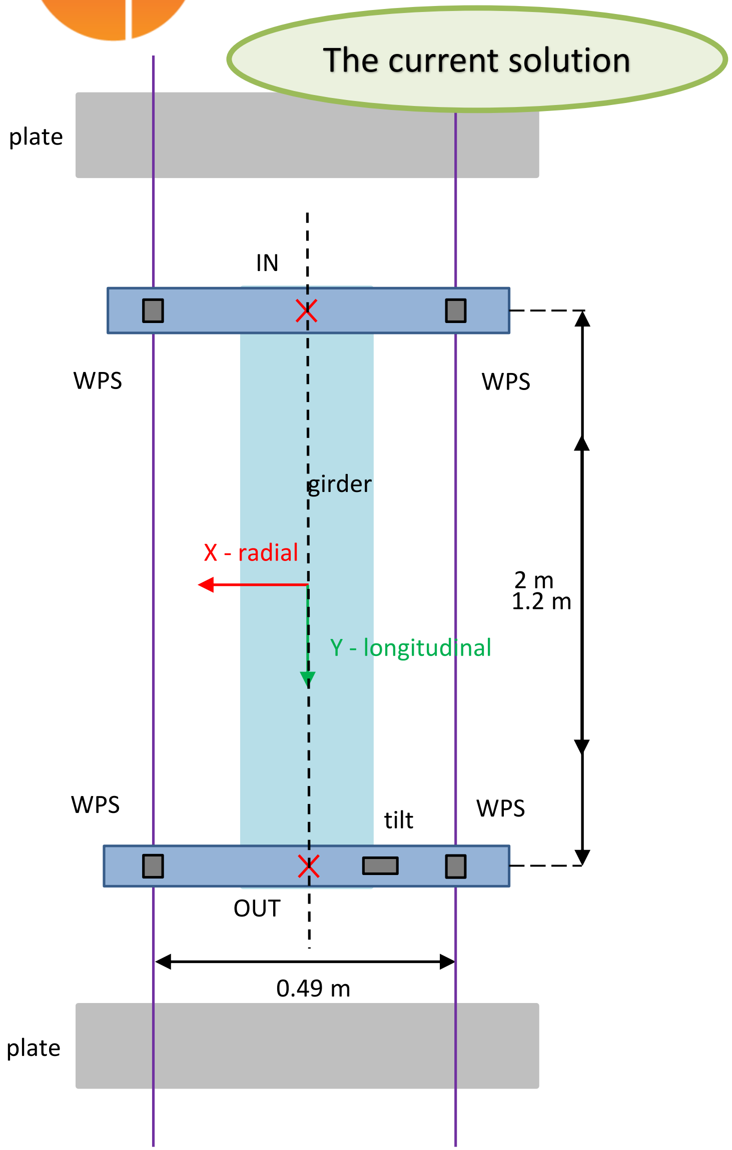
3. 1 tilt meter with an accuracy of 10 µrad

X [µm]	Z [µm]
12	10

4. 1 tilt meter with an accuracy of 60 µrad

X [µm]	Z [µm]
22	20

3. Estimated precision



Simulations:

- Length of the girder 2 m
- Coordinate frame in the middle of the girder
- Sensors located 20 cm lower than the main axis
- 0.49 m between sensors in the radial direction
- Longitudinal distance between sensors 2 m

2 wires:

Precision

5. both with an accuracy of 5 µm (cWPS)

X [µm]	Z [µm]
11	9

X – radial, Z – vertical

6. the first with an accuracy of 5 µm (cWPS), the second with 10 µm (oWPS)

X [µm]	Z [µm]
15	10

1 wire (with cWPS):

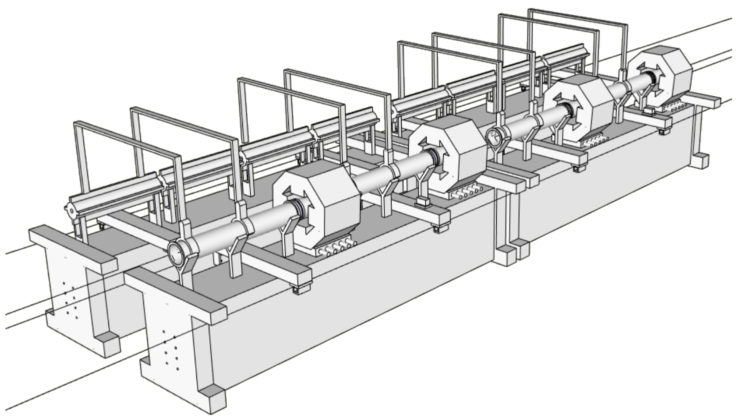
7. 1 tilt meter with an accuracy of 10 µrad

X [µm]	Z [µm]
14	12

8. 1 tilt meter with an accuracy of 60 µrad

X [µm]	Z [µm]
24	22

3. Conclusion on estimated precision



Shorter distance between sensors (-80 cm)

⇩

Lower precision of the axis' position (+2 μm)

<u>2 wires</u>

- Precision < 15 μm
- 8 observations (each sensor gives 2 values)
- 5 parameters to define (2 translations and 3 rotations of the girder)
- Difficult access between MB and DB girders – small distance, a lot of components which connect the two sides

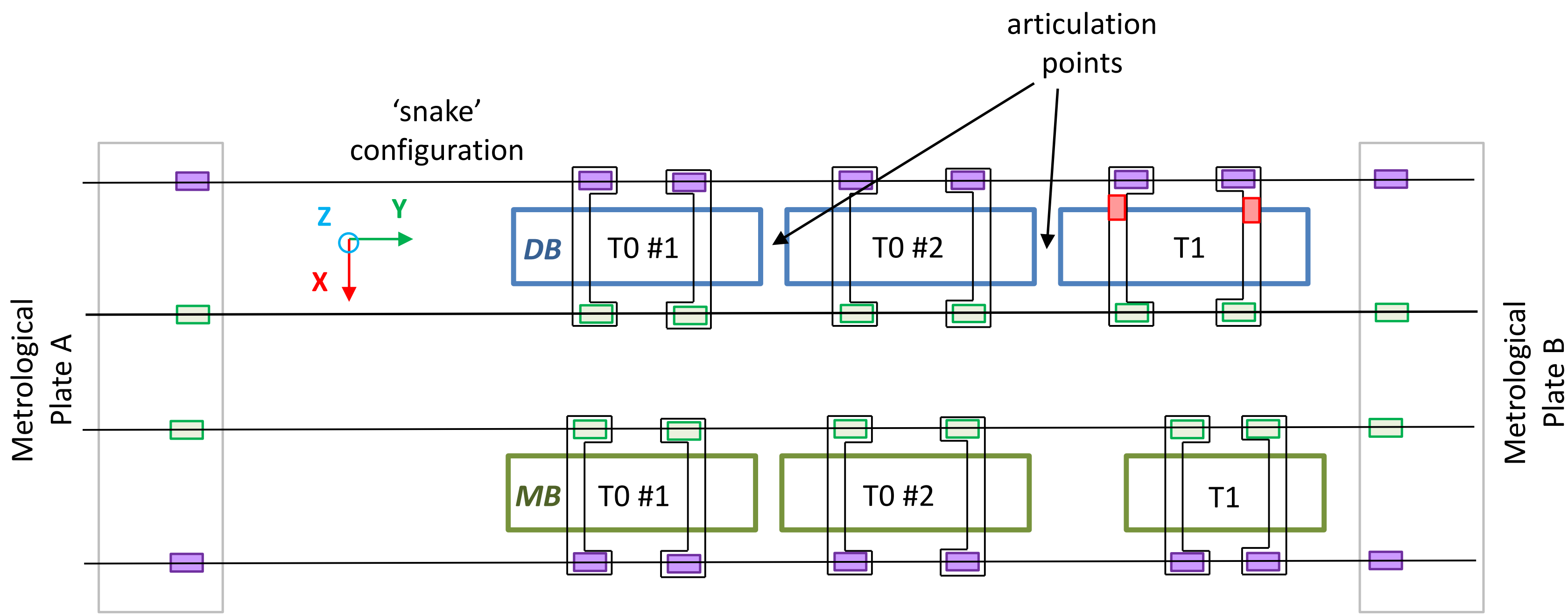
<u>1 wire + tilt meter (10 μrad)</u>

- Precision < 14 μm
- 5 observations (2 cWPS + angle from the tilt meter)
- 5 parameters to define
- No redundancy

<u>1 wire + tilt meter (60 μrad)</u>

- Precision < 25 μm
- 5 observations
- 5 parameters to define
- No redundancy

4. Configuration of the CLIC mock-up



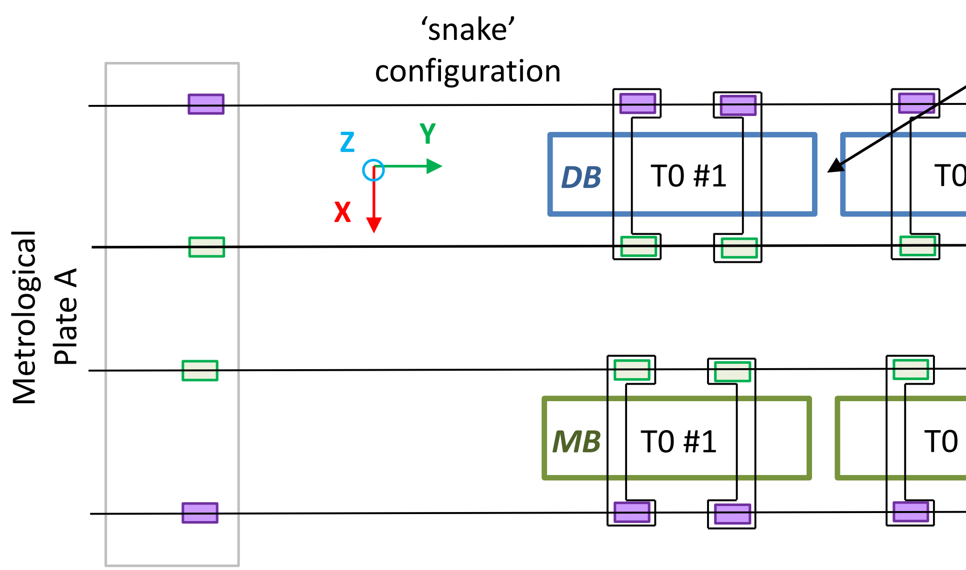
cWPS

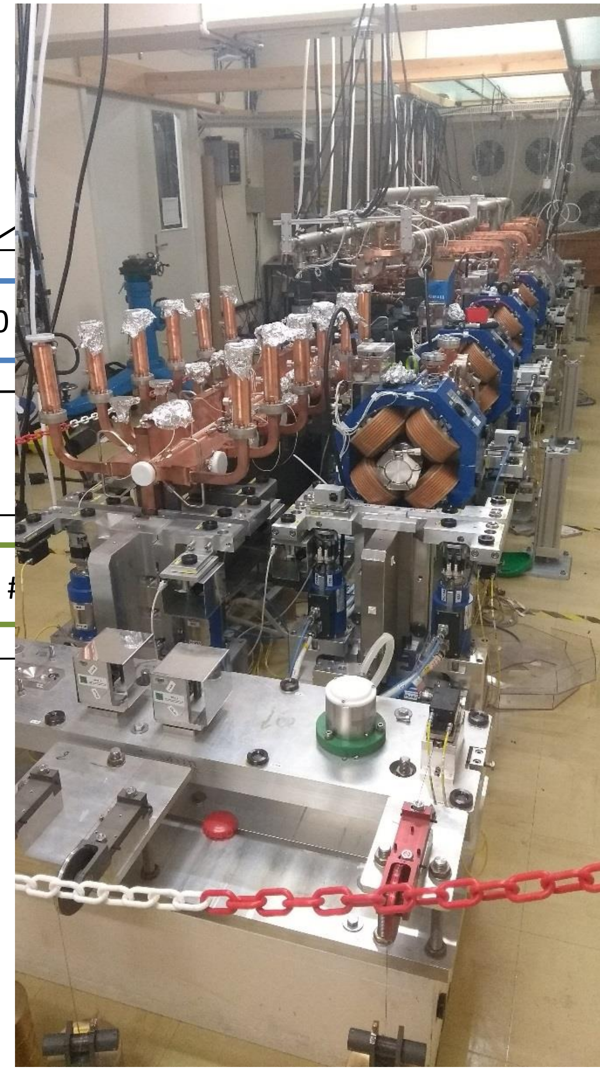
oWPS

tilt meter

In total:
- 6 girders
- 16 cWPS
- 16 oWPS
- 2 tilt meters
- 4 temperature probes
- 27 actuators for moving the girders

4. Configuration of the CLIC mock-up





cWPS
oWPS
tilt meter

In total:

- 6 girders
- 16 cWPS
- 16 oWPS
- 2 tilt meters
- 4 temperature probes
- 27 actuators for moving the girders

4. Active alignment – software

Actuator list

ACT_ID	ACT_NAME	ACT_TYPE	RESOLUTION	SERIAL_NUMBER	MOD_ID	MODULE_NAME
1	AVL_DBM1	ZTS_NEW	0.266		DB1	DBM1
2	AR_DBM1	ZTS_NEW	0.266		DB1	DBM1
3	AVR_DBM1	ZTS_NEW	0.266		DB1	DBM1

Metrology data

FIDUCIAL_ID	FIDUCIAL_TYPE	SENSOR_ID	SENSOR_NAME	SPHERE_NUMBER	POSITION	MODULE	X	Y	Z	FIDUCIAL_NAME
1	3	0		0	1	1	-623.4429	139.1445	-66.0021	PA-1
2	3	0		0	1	1	-228.9647	143.5128	-66.0971	PA-2
3	3	0		0	1	1	217.3304	143.5836	-66.1123	PA-3
4	3	0		0	1	1	619.267	144.76	-65.9961	PA-4
5	3	0		0	1	1	622.6362	-104.9288	-66.0268	PA-5
6	3	0		0	1	1	220.0746	-103.2516	-66.0519	PA-6
7	3	0		0	1	1	-219.2091	-104.1527	-66.1327	PA-7
8	3	0		0	1	1	-619.7365	-102.7886	-65.997	PA-8
9	2	23	ODB1	1	1	1	-34.5205	17.815	-74.6261	PAB-O1
10	2	23	ODB1	2	1	1	-55.5862	90.803	-74.6394	PAB-O2
11	2	23	ODB1	3	1	1	-76.5281	17.7743	-74.6513	PAB-O3

Sensor list

SENSOR_NAME	TYPE_ID	WIRE	MODULE	SENSOR_TYPE	SERIAL_NUMBER	POLY_FILE
CDB1	1	1	1	CWPS	7D7-032	c:\ni-rt\APP\POLYF
CDB2	1	1	3	CWPS	7DE-015	c:\ni-rt\APP\POLYF

Software

Laser tracker data

FIDUCIAL_	X	Y	Z	FIDUCIAL_	MODULE
1	-307.177	-2565.71	-290.495	PA-1	1
2	87.2992	-2561.18	-290.56	PA-2	1
3	533.5942	-2560.94	-290.537	PA-3	1
4	935.5303	-2559.6	-290.387	PA-4	1
5	938.9992	-2809.29	-290.157	PA-5	1
6	536.4369	-2807.77	-290.219	PA-6	1

Position of the girders' axes

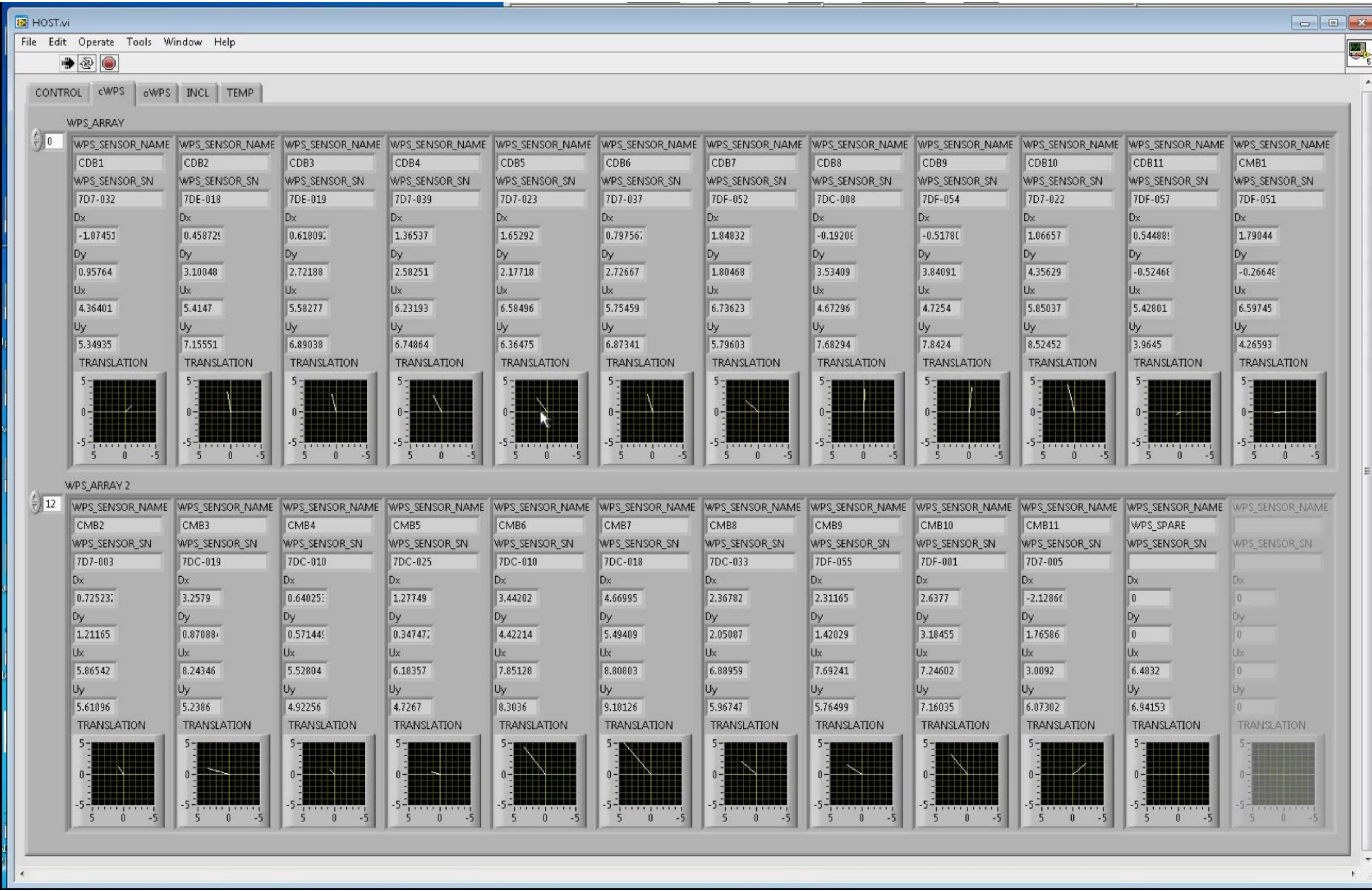
DBM2_OUT_X	DBM2_OUT_Y	DBM2_OUT_Z	DBM2_Ry	DBM3_IN_X	DBM3_IN_Y	DBM3_IN_Z
-0.012	2000.101	-0.089	0.000263	-0.015	2010.152	-0.018
-0.012	2000.101	-0.089	0.000263	-0.015	2010.152	-0.017
-0.012	2000.101	-0.089	0.000263	-0.015	2010.152	-0.017

Sensors readout

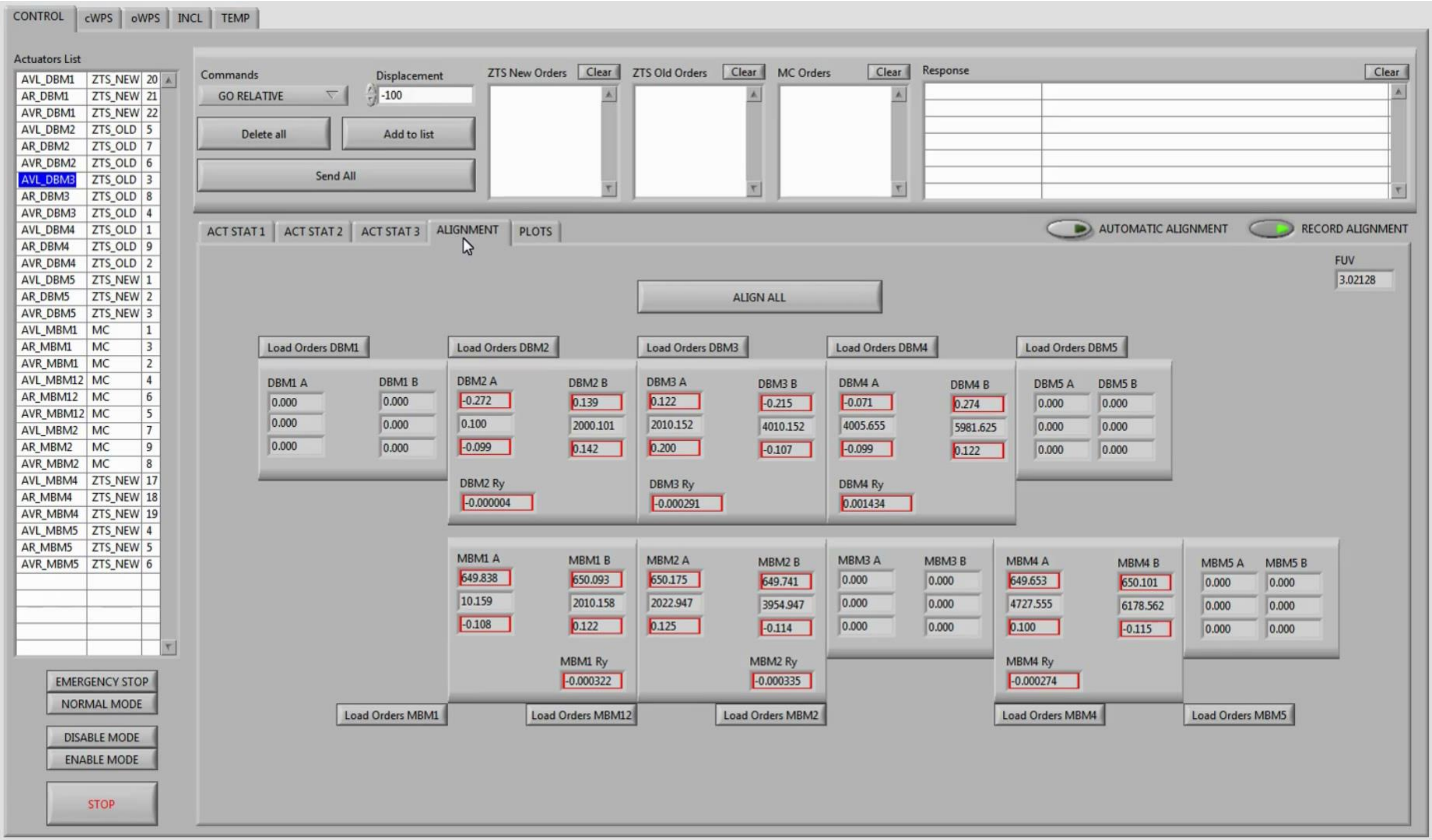
CMB11 Ux	CMB11 Dx	CMB11 Uy	CMB11 Dy	ODB1 Dx	ODB1 Dy
5.4108	0.6074	6.0982	1.7615	36.7812	63.6624
5.4107	0.6073	6.0978	1.7612	36.7822	63.6619
5.4107	0.6073	6.0978	1.7612	36.7822	63.6619

4. Active alignment

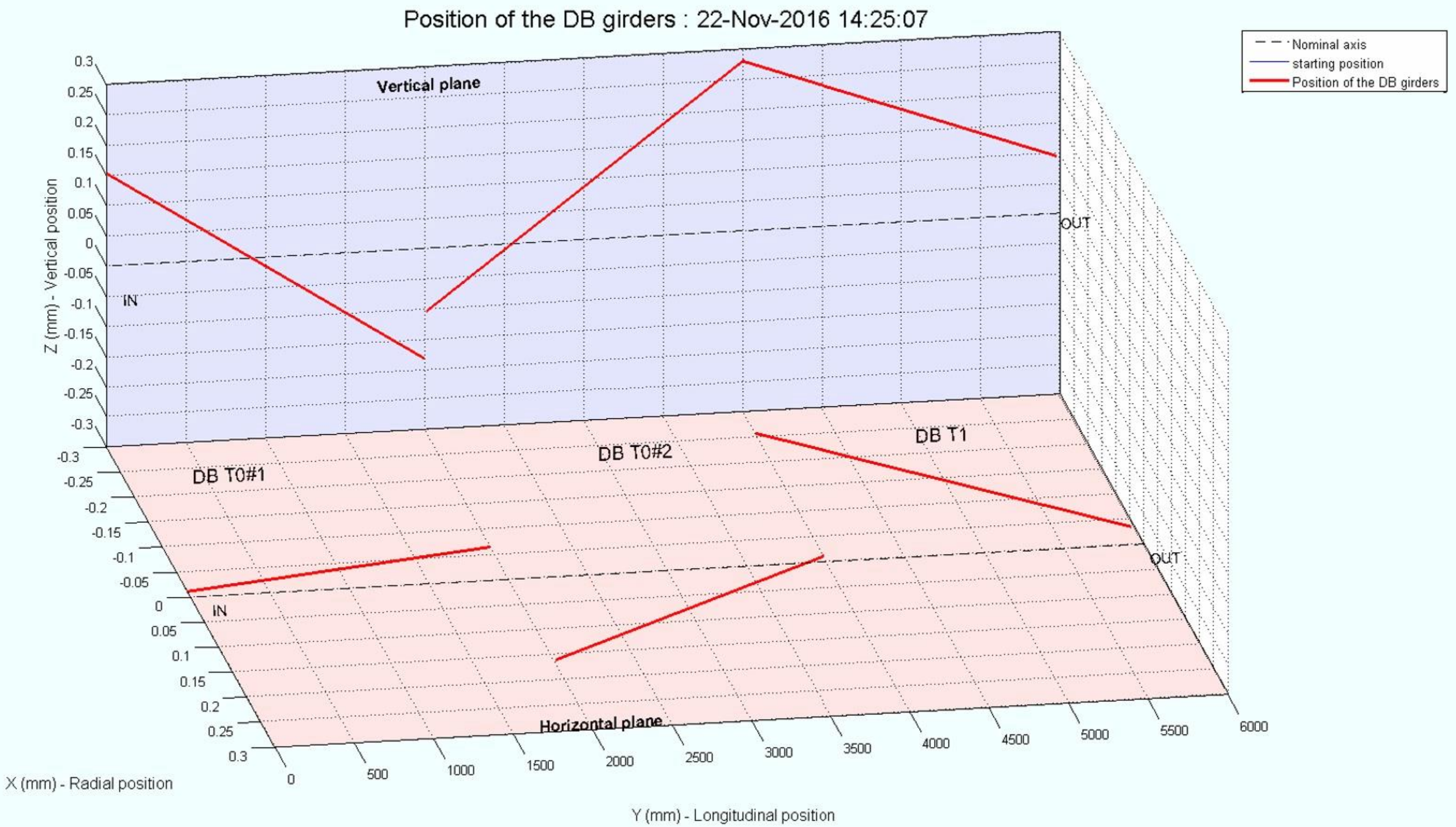
User interface with real-time indication of the beam position and the sensors



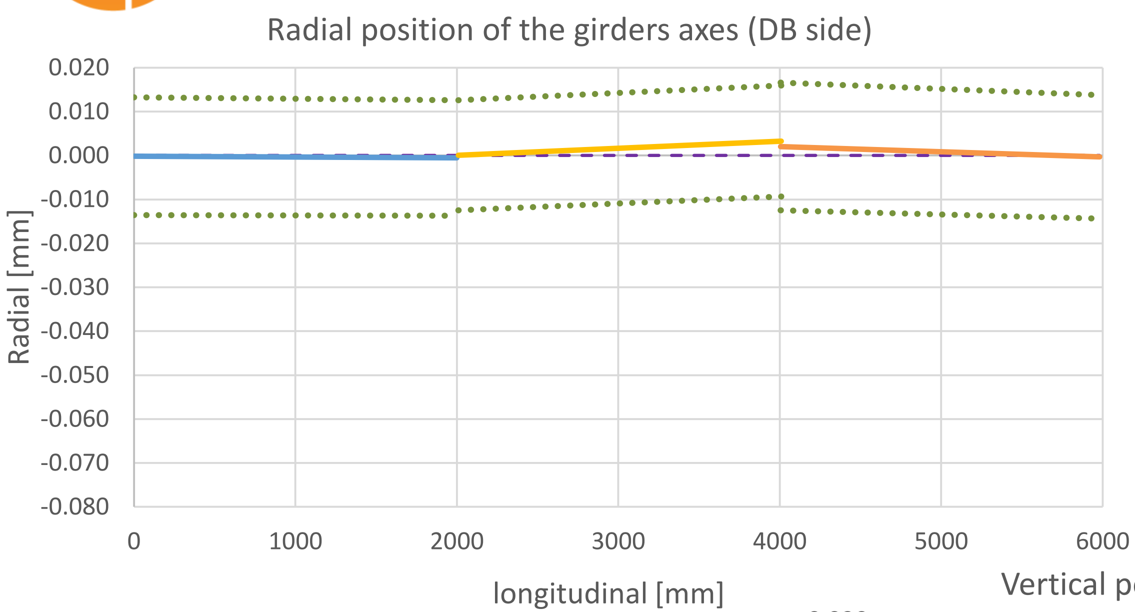
4. Active alignment



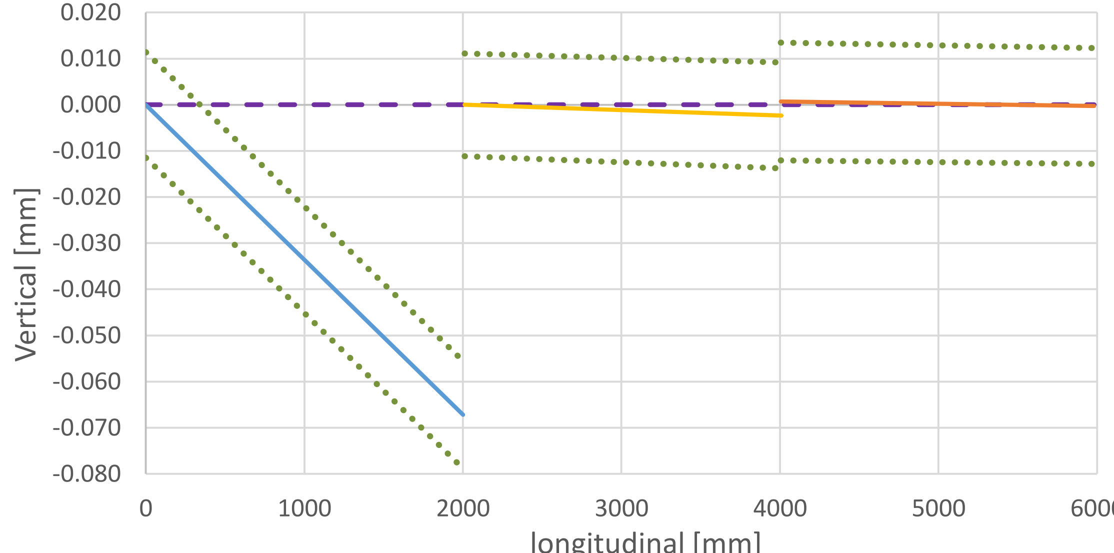
4. Active alignment response



4. The results of active alignment

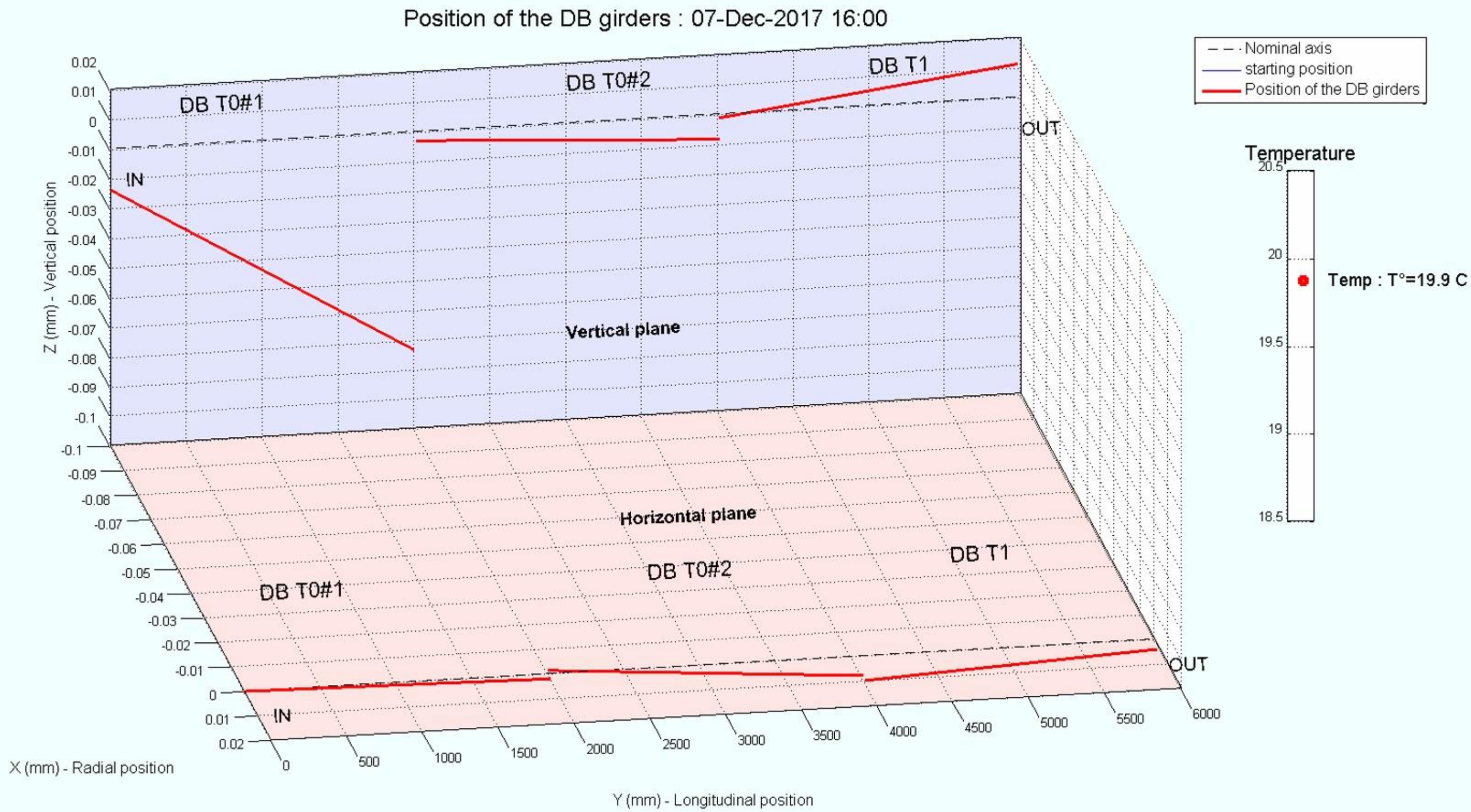


Precision comparable with the estimated one



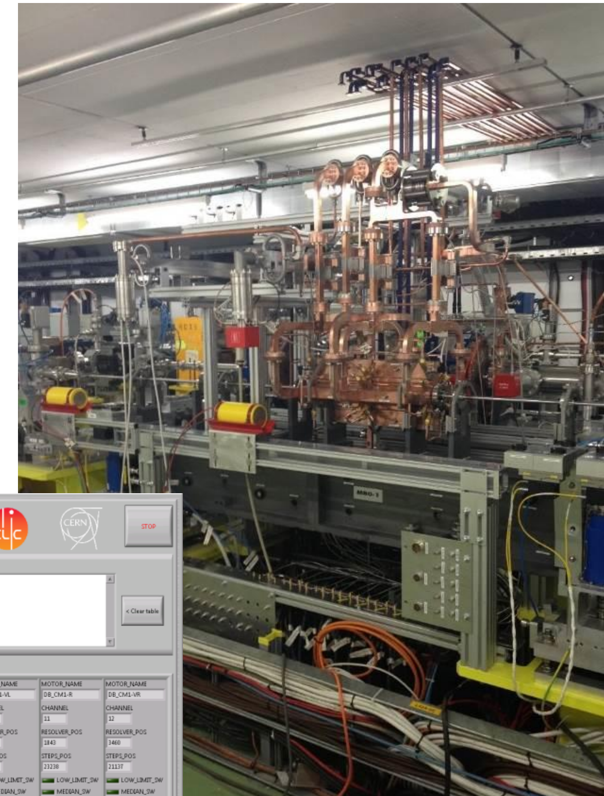
4. Good stability of the mock-up

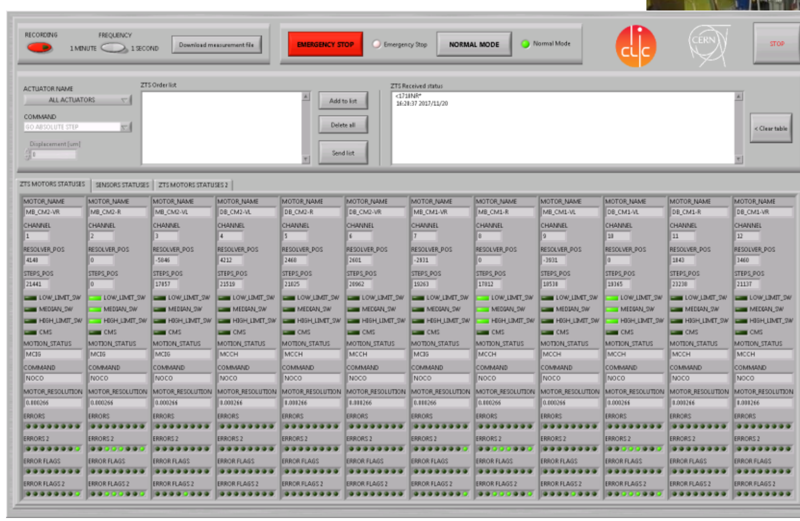
Position of the DB girders during one month
(07.12.2017 16:00 – 06.01.2018 08:00)



5. CLEX / CLEAR

- Configuration based on two wires per girder with cWPS
- Has already worked for several years in CLEX / CLEAR facilities
- The girder can be repositioned to demanding positions during physics tests
- No active alignment
- Position of the girder has to be calculated by separate software





6. Conclusion

- Current solutions (with available sensors) can in two cases provide axis-precision below 14 μm: 2 wires with cWPS or 1 wire and tilt meter with an accuracy of 10 μrad
- At a fixed temperature of 20°C, the stability over 10 days is below 5 μm in the radial direction, while it is below 10 μm in the vertical position
- The software provides fast and precise alignment of the girders
- The implemented solution, tested in realistic conditions (CLEX / CLEAR), gives satisfying results

Thank you for your attention

Special acknowledgements to Vivien Rude, Mateusz Sosin and Hélène Mainaud Durand