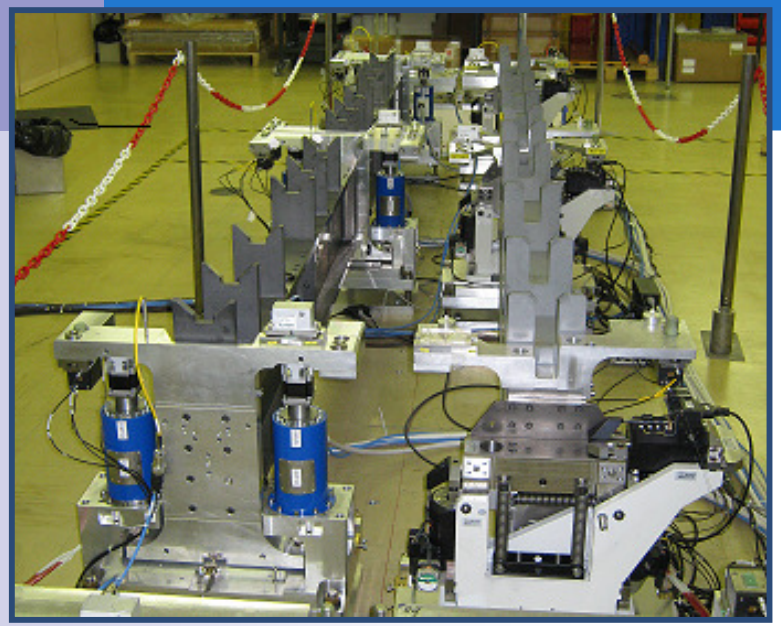
Qualification of and adjustment solution for CLIC active pre-alignment on test modules



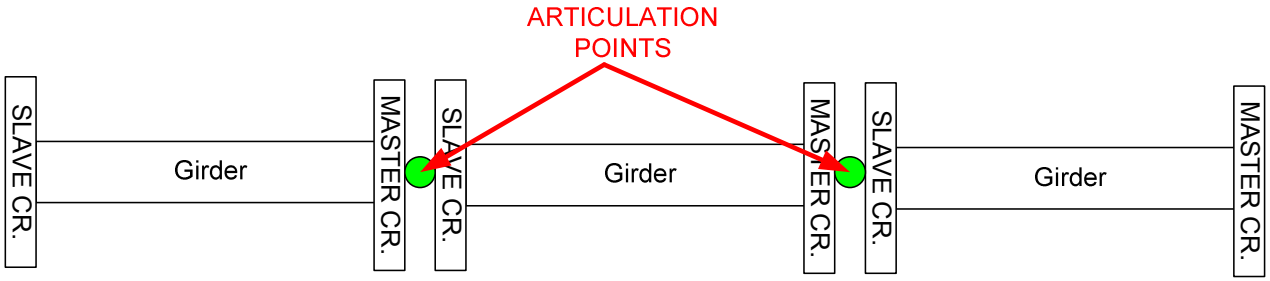
Mateusz Sosin

on behalf of the CLIC active pre-alignment team

Summary

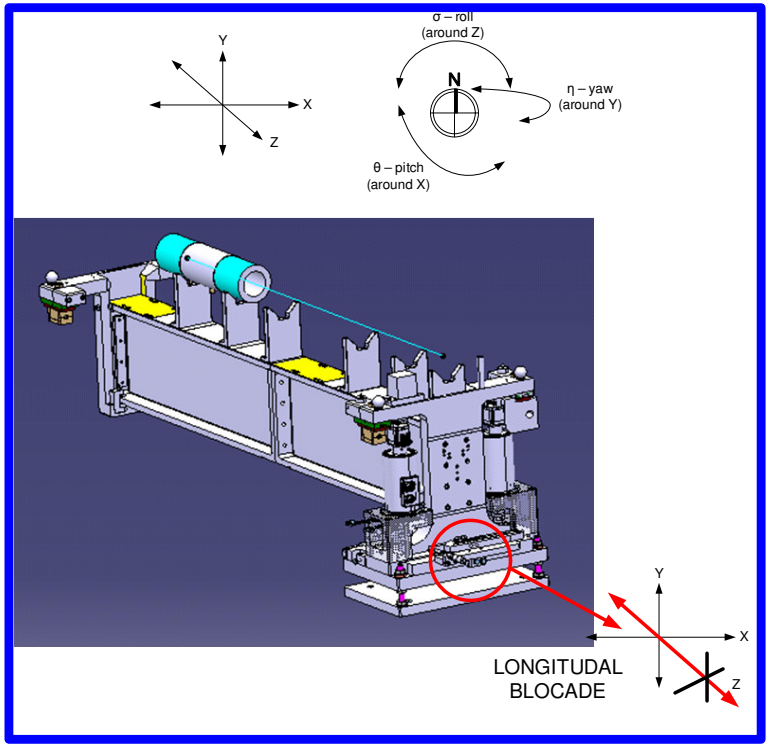
- Alignment philosophy
- Alignment requirements
- Actuators tests
- Adjustment solution and TM0 tests results
- Summary

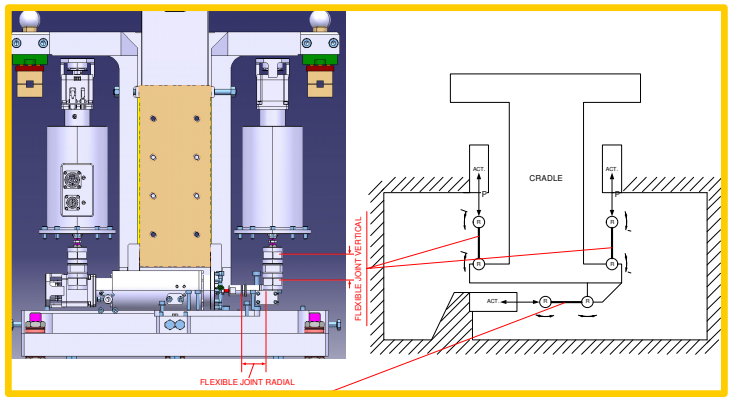
Alignment philosophy

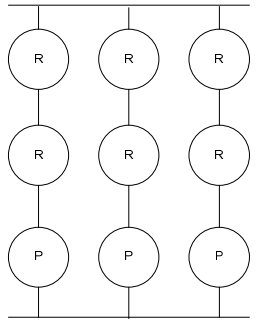


5DOF

3DOF







- **Cradle works in triple, parallel P-R-R (prismatic-rotation-rotation) kinematic circuit which is an simplified 2D – <u>3 support - Stewart platform with Fixed Actutators</u>**

Alignment requirements

Accelerating Structure Alignment

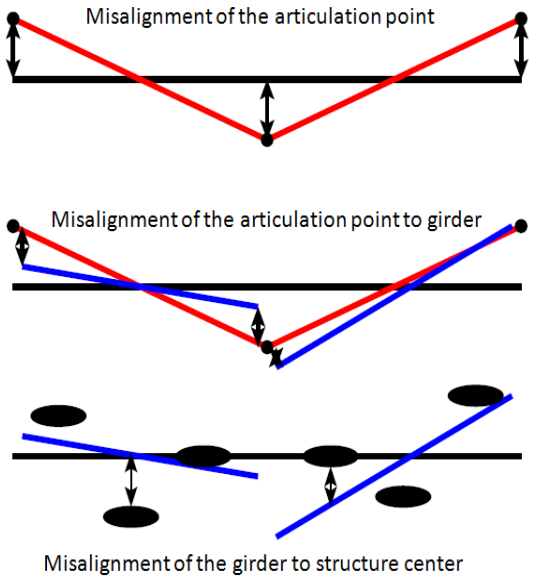
PRE-ALIGNMENT

Ref.	1	Inherent accuracy of reference	10 μm	1σ
Ref. to cradle	2	Sensor accuracy and electronics (reading error, noise,..)	5 μm	1σ
	3	Link sensor/cradle (supporting plates, interchangeability)	5 μm	1σ
Cradle to girder	4	Link cradle/girder	5 μm	1σ
Girder to AS	5a 5b	Link girder/acc. structure Inherent precision of structure	5 μm	1σ
		TOTAL Tolerance	14 μm 40 μm	1σ 3σ

BEAM-BASED ALIGNMENT

6) relative position of structure and BPM reading 5 μm 1σ

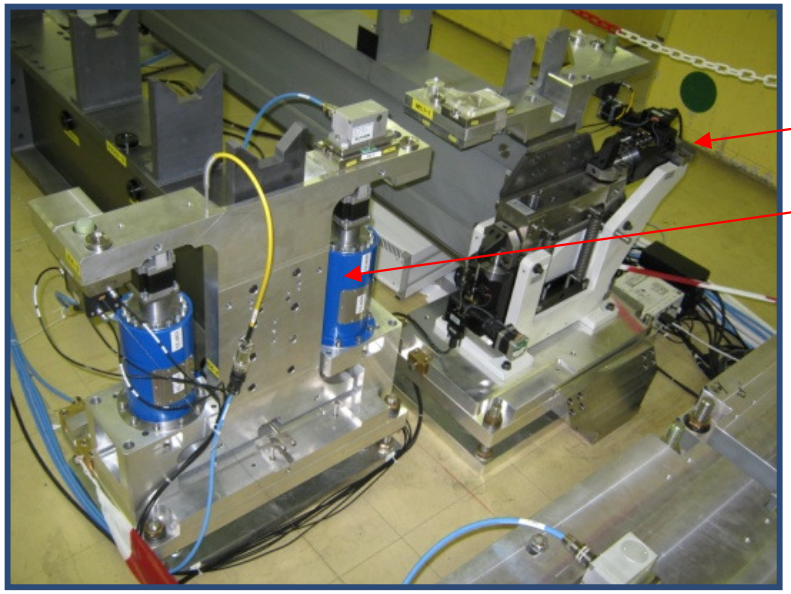
From D. Schulte, CLIC meeting, 04/05/2007.



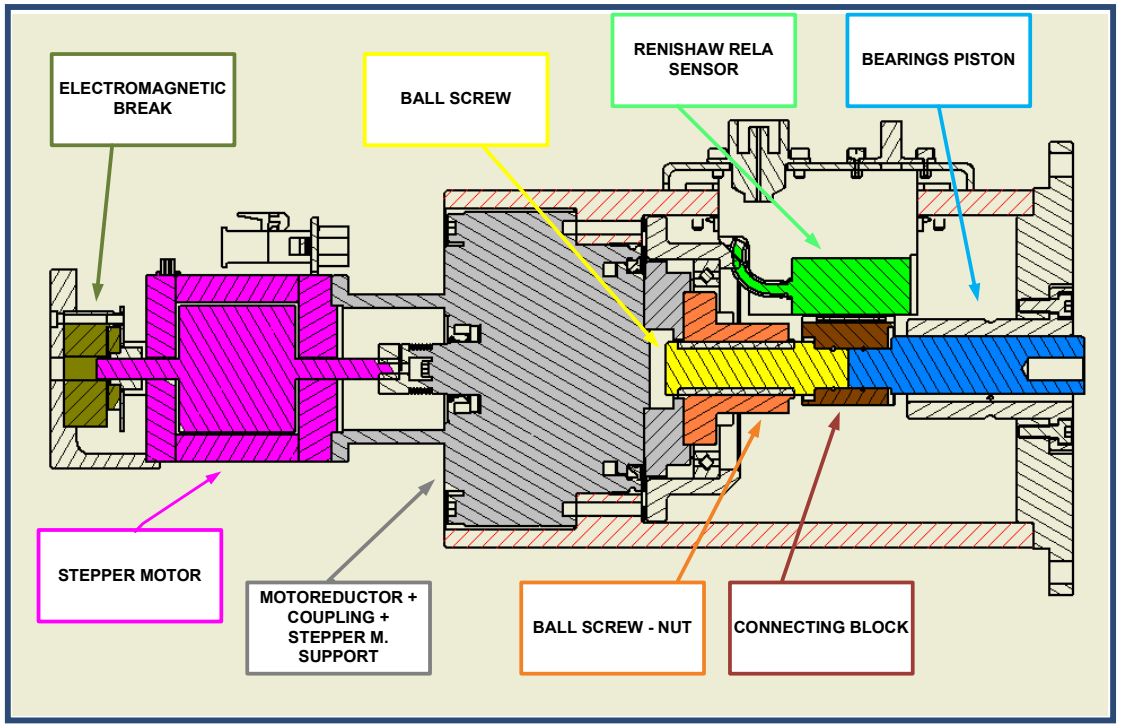
- **To provide proper adjustment**
  - ✓ Elements machined w.r.t. defined tolerances
  - ✓ Whole elements fiducialized (accurately and precisely known geometry of cradle-girder-cradle and w.r.t. cradle of next girder)
  - ✓ High resolution precise actuators

- **Actuators**
  - ✓ Good repeatibility (<1μm)
  - ✓ Resolution below 0.5μm
  - ✓ No loss of steps, no (or minimal and known) hysteresis
  - ✓ High stiffness & linearity
  - ✓ Stroke +/-3mm

Actuators tests

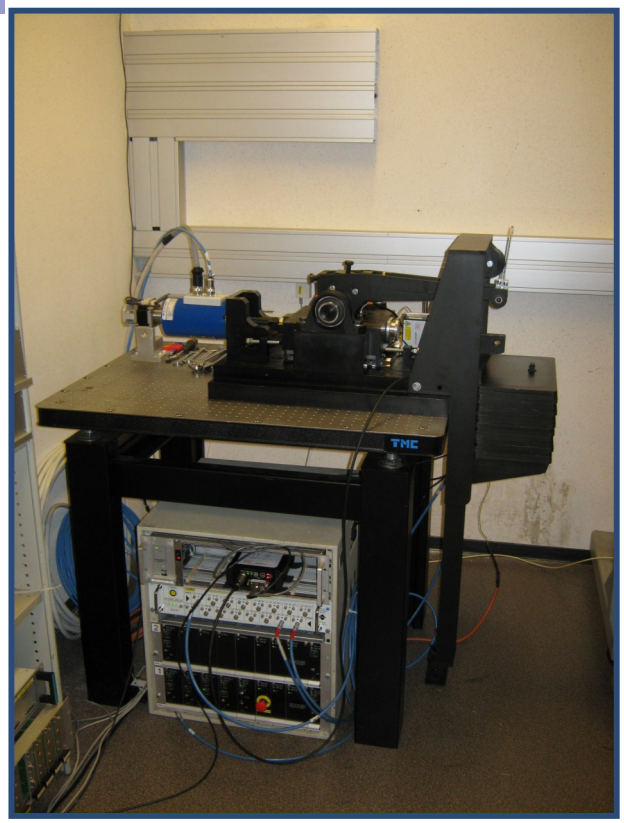


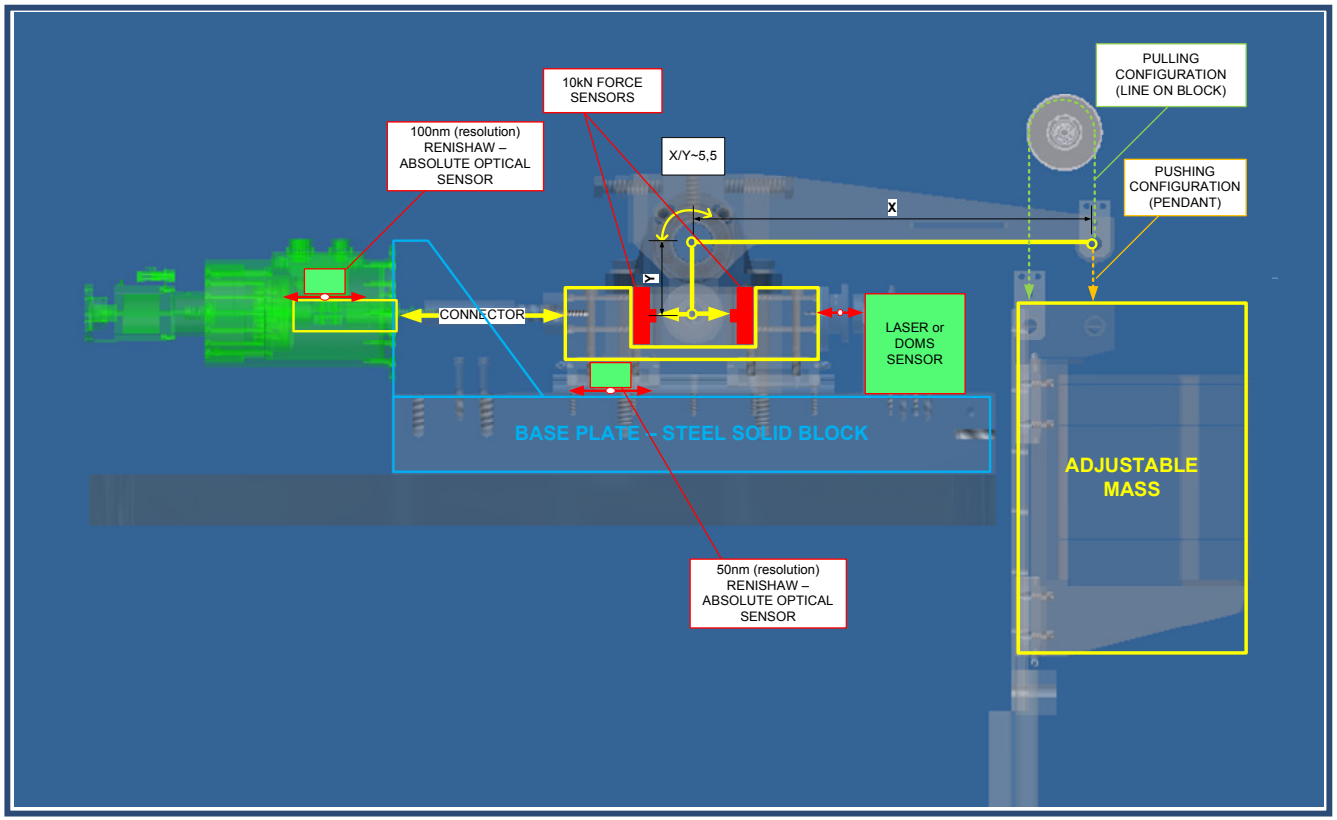
- **Two types of actuators used at TM0**
  - ✓ MICROCONTROLE
  - ✓ ZTS VVU Kosice - Slovakia
  - ✓ Both construction using ball screws based mechanisms
  - ✓ **<u>Very high precision of machining requested to suppliers</u>**

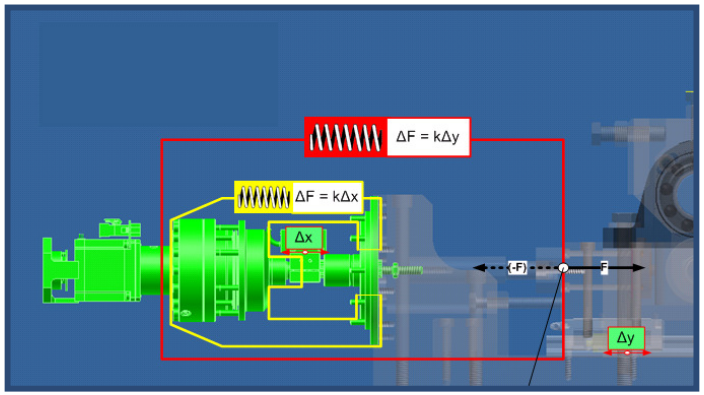


- **Only ZTS tested completely at special developed test bench**
- **MICROCONTROLE tested only at TM0**

Actuators tests – test bench

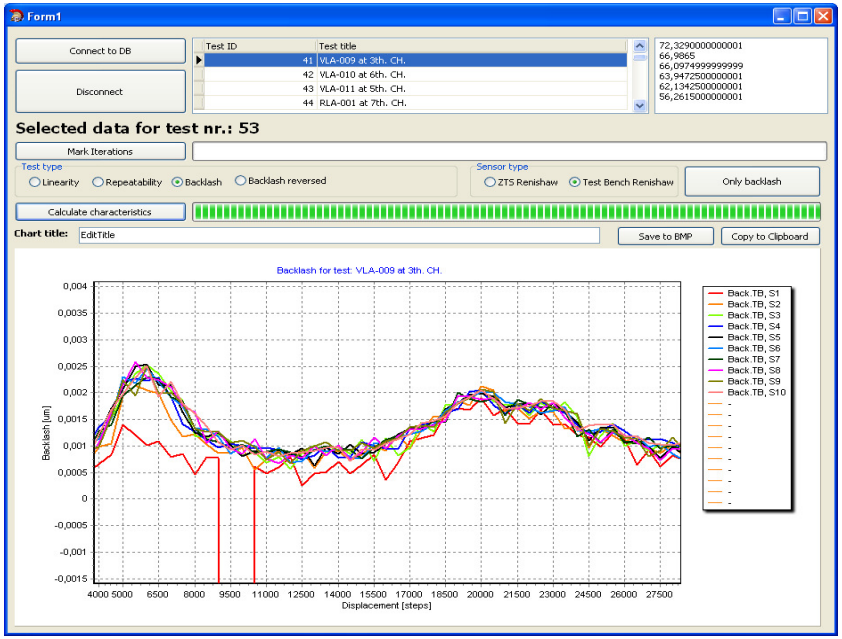






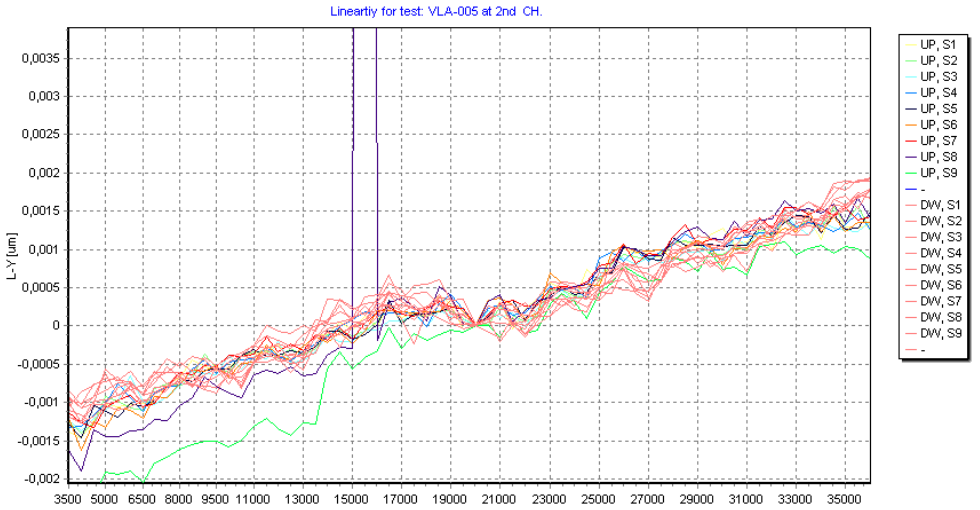
- **Special test bench developed:**
  - ✓ Possibility to 800kg load applying
  - ✓ Adjustable load
  - ✓ PUSHING and PULLING configuration
  - ✓ Hysteresis/backlash, repeatibility, linearity, stiffness measurements

Actuator tests - results

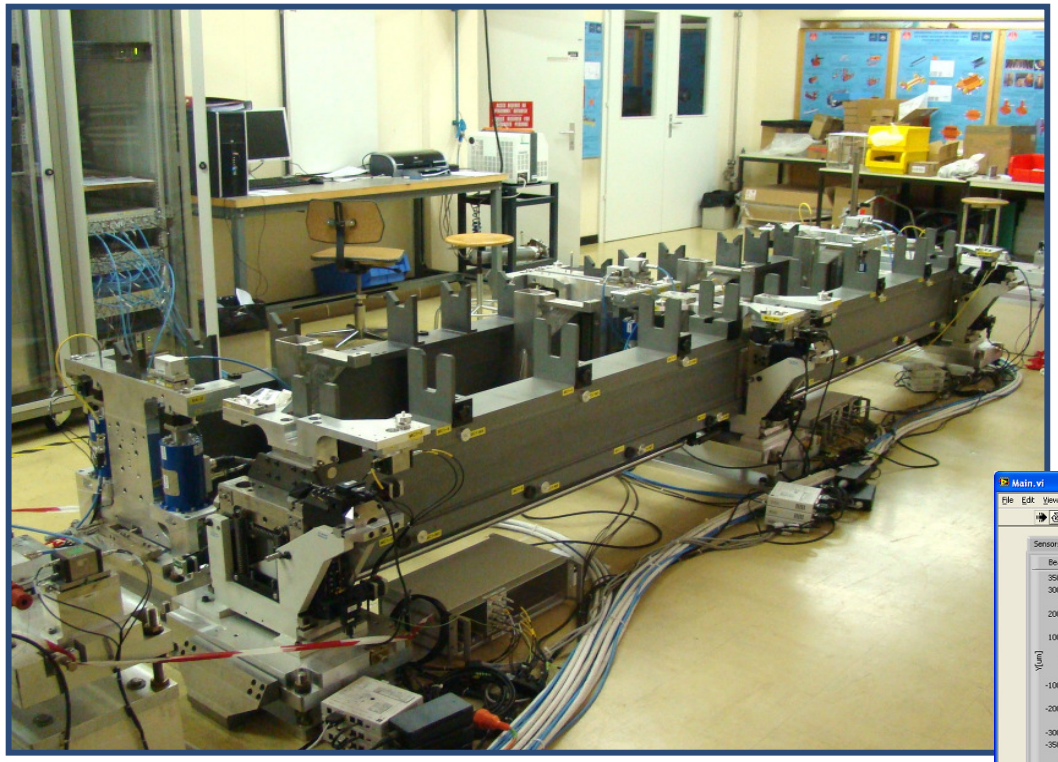


- **All full-range characteristics taken for ZTS actuatros**
  - ✓ Max. nonlinearity 3µm (at +/-3mm range)
  - ✓ Max. hysteresis 4µm (at full 650kg load)
  - ✓ Resolution below 0.2µm
  - ✓ Repeatibility 1..1.5µm
  - ✓ Characteristics ready to use in control system as calibration curves if needed

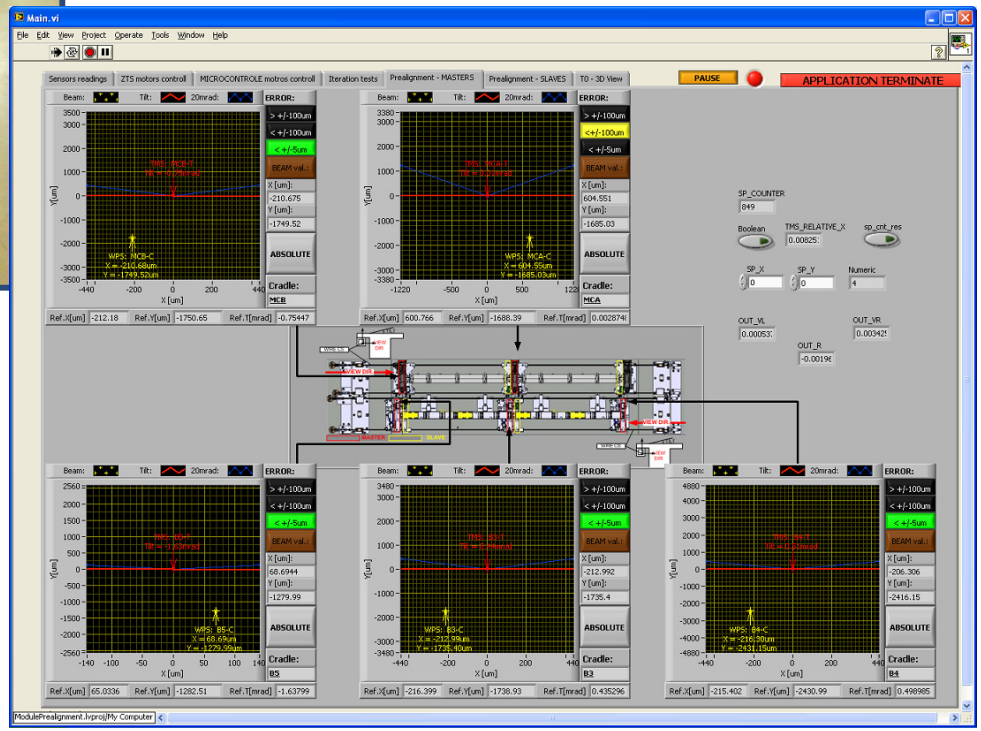
- **Microcontrole actuators tested only at TM0**
  - ✓ Max. backlash 2µm
  - ✓ Resolution below 0.2µm



Adj. solution and TM0 tests results



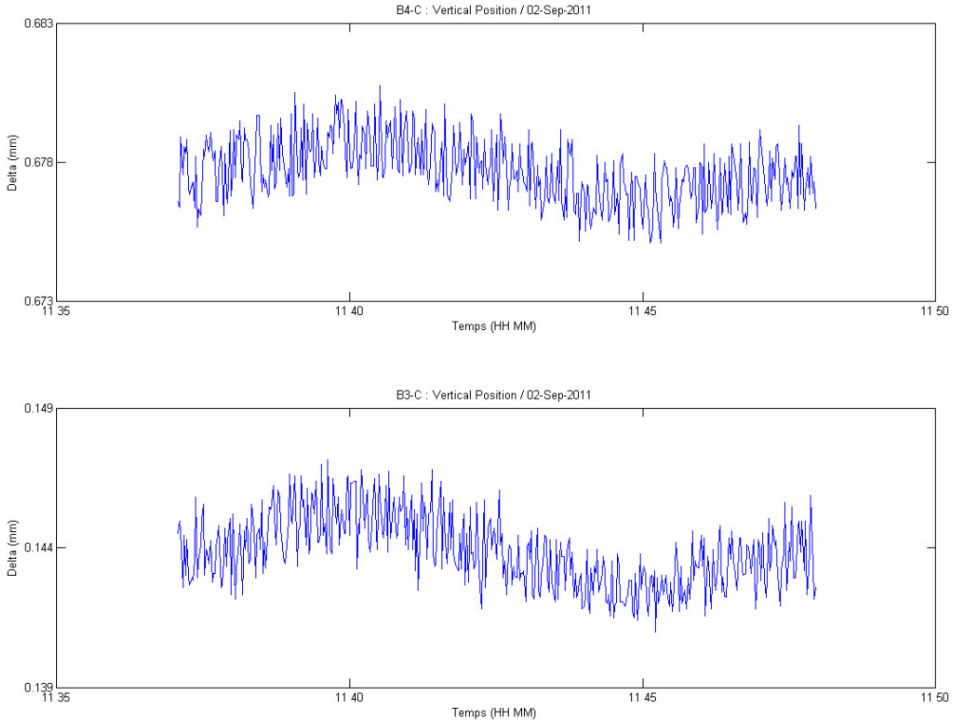
- **Two T0 modules at CERN lab**
  - ✓ Drive beam: BOOSTEC girders solution + ZTS actuators
  - ✓ Main beam: MICROCONTROLE girders solution + MICROCONTROLE actuators

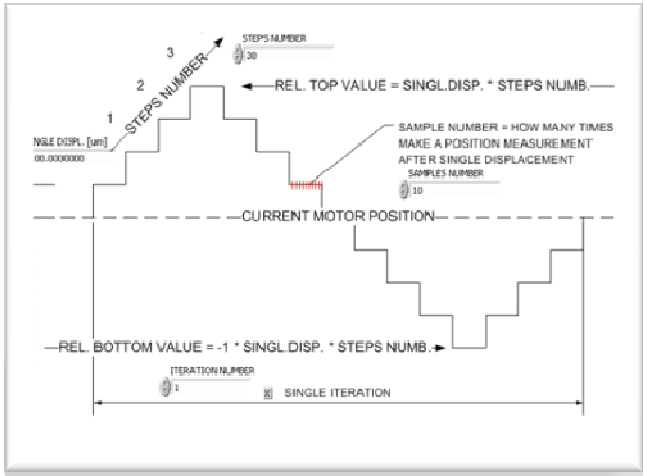


- **Control system for TM0**
  - ✓ X-Y measurement by WPS sensors
  - ✓ Tilt measurements by precision dual axis inclinometers
  - ✓ Software - LabView based (handling data acq., visualizaion & control algorithms

Adj. solution and TM0 tests results

- **Actuators parameters measurements in TM0 (in range +/- 1mm, relative displacements)**
  - ✓ For ZTS actuators – TM0 tests confirmed values obtained at previous (test bench) tests
  - ✓ MICROCONTROLE actuators parameters were measured:
    - Resolution : less than 0.2 micron
    - Max. Backlash: 2µm
    - Good repeatibility within 2µm

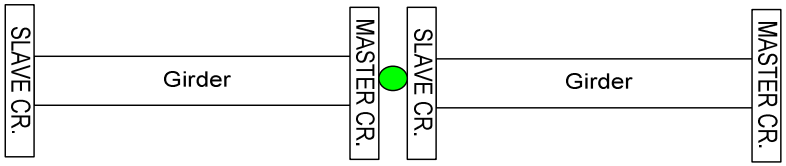




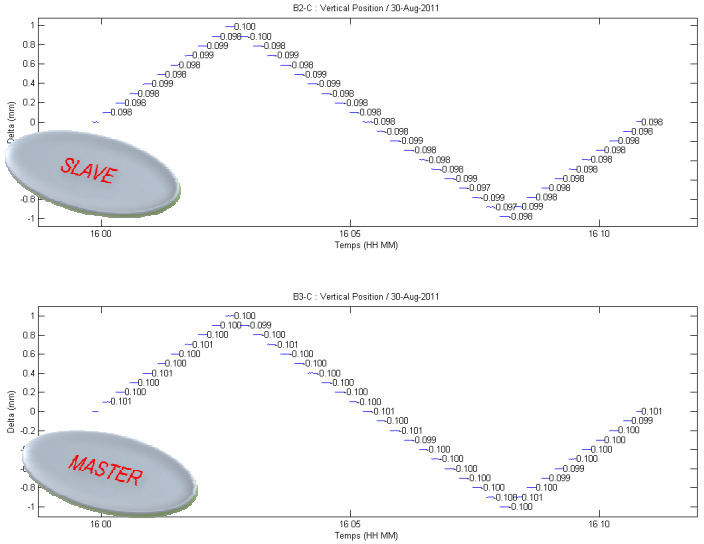
By Vivien Rude, CERN, BE-ABP-SU

Adj. solution and TM0 tests results

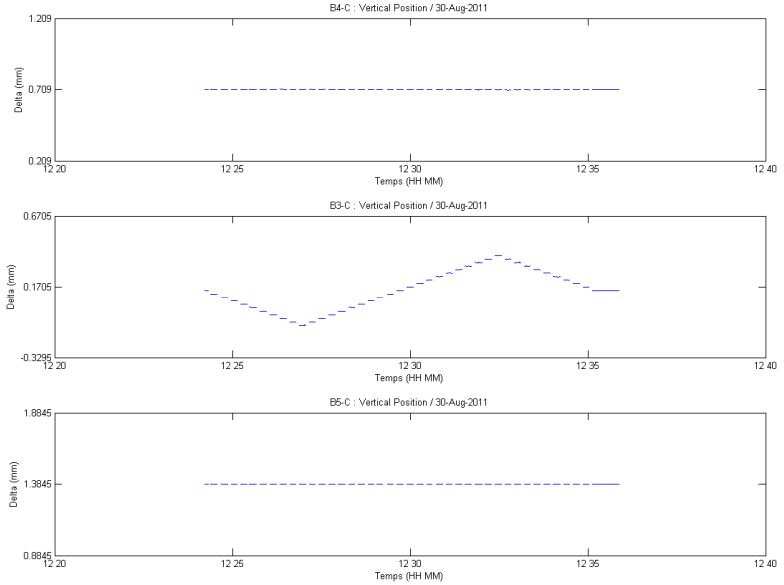
- **Master<->Slave articulation point validation**
  - ✓ Relative transversal & vertical displacements confirmed same translations on connected master and slave cradles (SLAVE cradle is following the MASTER)
  - ✓ Displacements of one master-slave pair not affect for position of neighbouring cradles
  - ✓ No cradle rotation during parallel driving of vertical actuators



Vertical cradles displacements for BOOSTEC



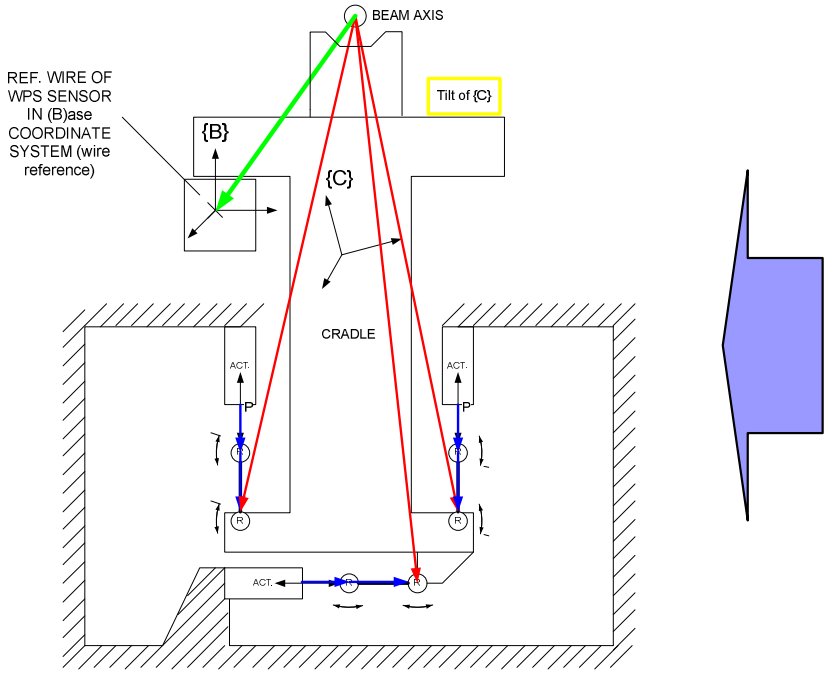
Rotations for BOOSTEC girders

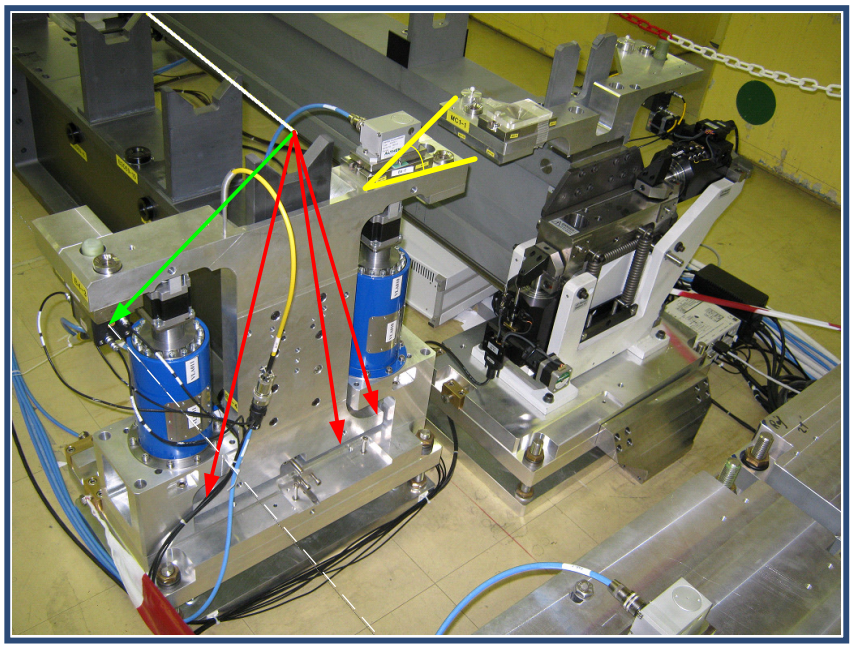


By Vivien Rude, CERN, BE-ABP-SU

Adj. solution and TM0 tests results

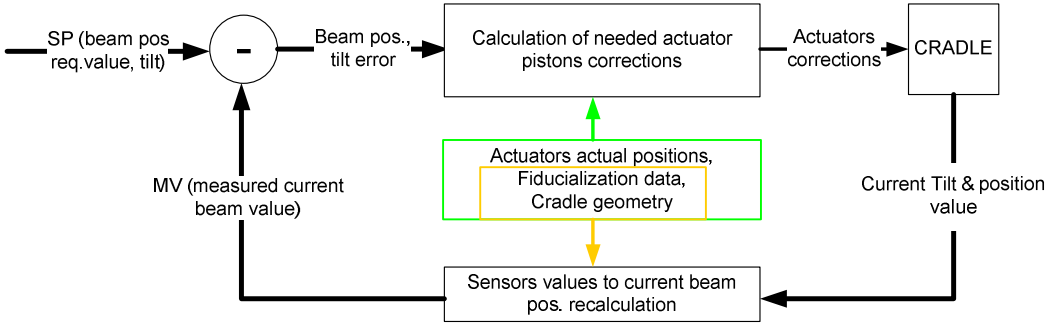
- **Data used for 3DOF cradle alignment:**
  - ✓ Cradle & girder geomerty w.r.t. beam axis (project definition & measurements)
  - ✓ Last actuator & flexible joints vectors positions (known pos. & param.)
  - ✓ Beam position w.r.t reference wire (sensor calibration & sensor-support/cradle fiducialization based)
  - ✓ Tilt (sensor calibration & sensor-support/cradle fiducialization based)

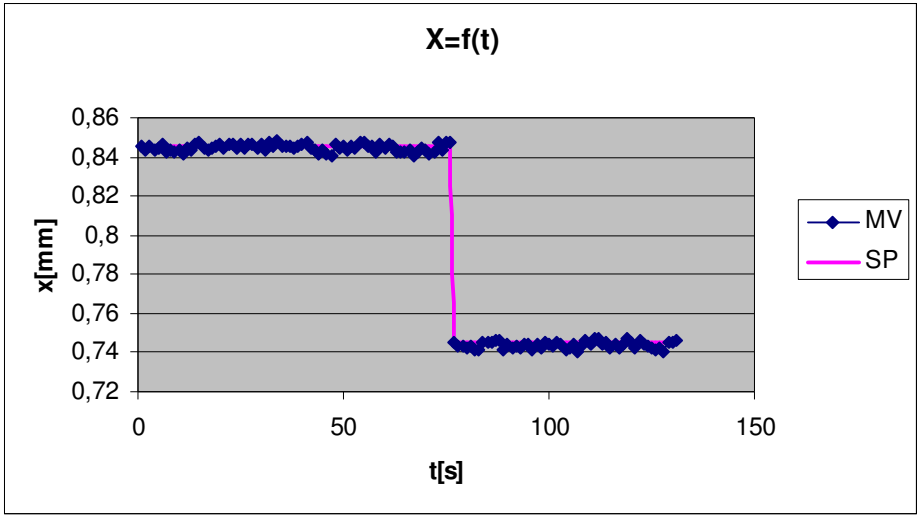


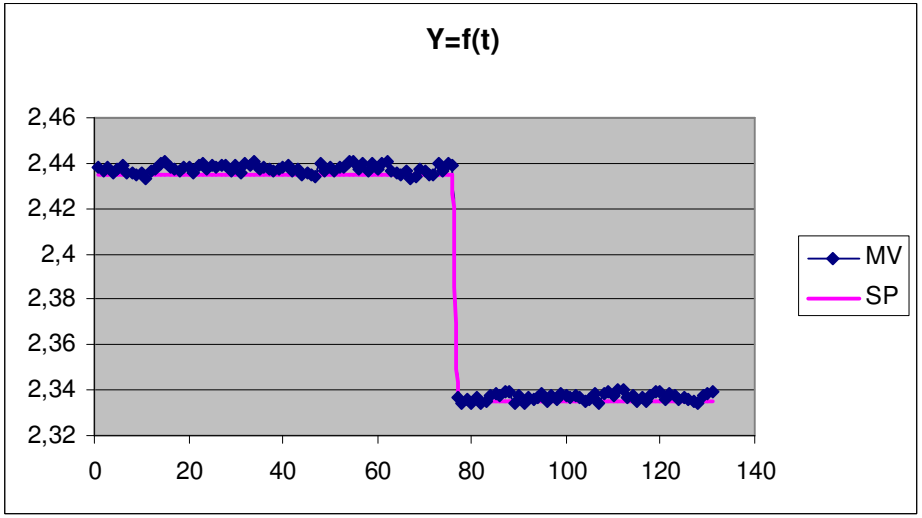


Adj. solution and TM0 tests results

- **Regulation**
  - ✓ Proportional method based on fiducialization and sensors calibration data
  - ✓ Tests only for relative displacements – absolute sensors calibrations pending
  - ✓ Tests in noisy area – standard deviation of WPS measuremets within ~1.3µm
  - ✓ Regulation results confirm Set Point tracking within noise of the WPS sensor

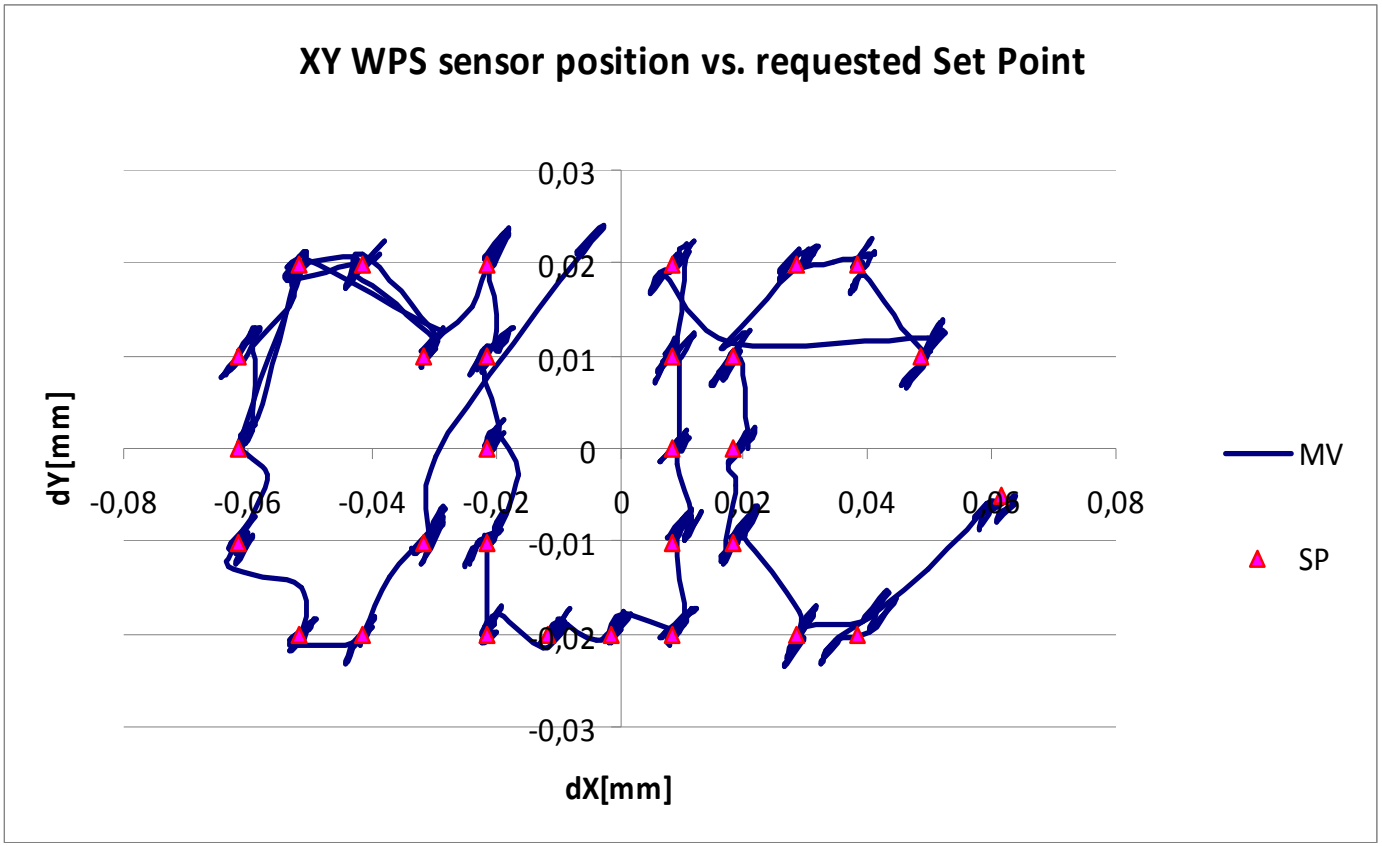






Adj. solution and TM0 tests results

- **Regulation**
  - ✓ Best possible quaility of regulation to be checked after improving sensors performance
  - ✓ Regulation anglorithm checked & works fine within +/-1.3µm sensor noise
  - ✓ Quality of regulation achieved for big displacement of +/-1mm



Summary

- **What was done:**
  - ✓ Conception of Master-Slave based structures adjustment checked and gives promising results for future
  - ✓ Closed loop regulation – now only for relative displacements – show that adjustment of cradles is feasible within specified precision

- **Future works:**
  - ✓ Validate the fiducialisation strategy on the two beam modules prototypes as well as short range pre-alignment. We are still learning new things linked with absolute measurements
  - ✓ Improve the performance of different sensors, perform their qualification and perform qualification of regulation based on that sensors feedback