Issues and Feasibility Demonstration of CLIC Supporting System Chain Active Pre-Alignment Using a Multi-Module Test Setup

M. Sosin, M. Gutt-Mostowy, J. Kemppinen, Z. Kostka, J. Jaros, H. Mainaud-Durand, A. Zemanek, CERN, Geneva, Switzerland
V. Rude, ESGT-CNAM, Le Mans, France

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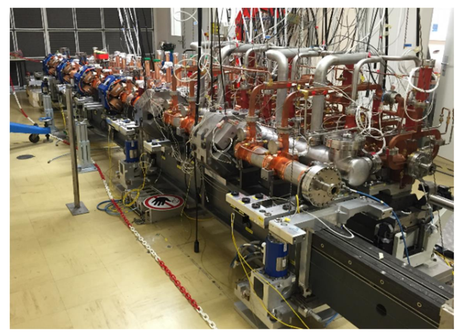
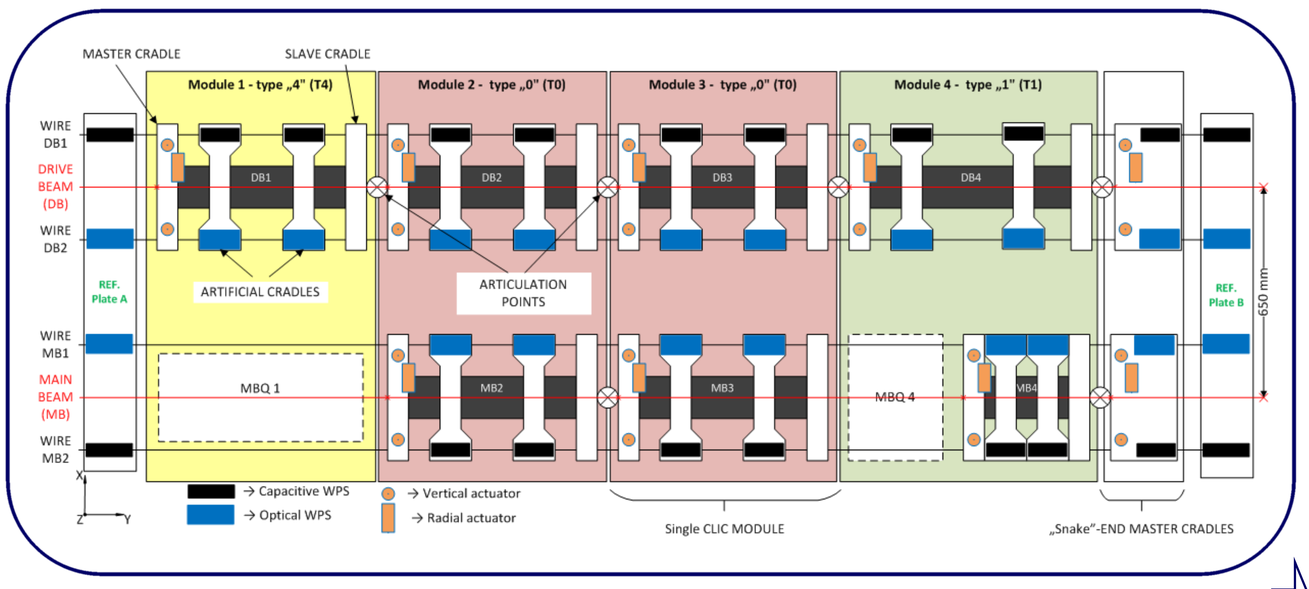
Introduction

The most critical CLIC RF components need to be pre-aligned within 14 µm rms with respect to a straight reference line along a sliding window of 200 m.
A system based on supporting structures (girders and cradles) connected in “snake”-type configuration and equipped with linear actuators is being tested. A special test mock-up was built at CERN to demonstrate, the feasibility of remote active pre-alignment within tight tolerances.

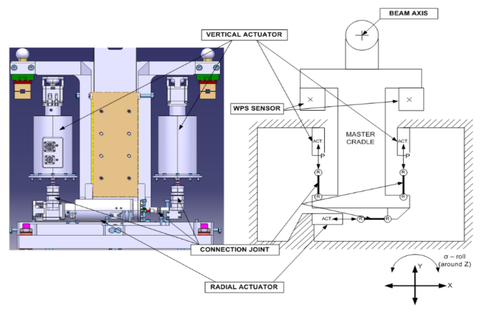


CERN CLIC mock-up



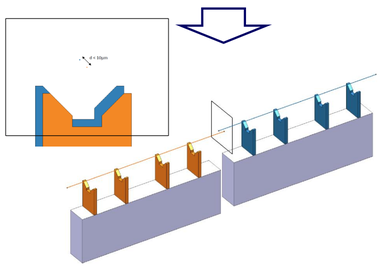
„Snake”-type girders configuration - smooths out “naturally” the pre-alignment of adjacent girders

- CLIC RF components installed on modular girders
- Motorization will be installed at one side of a girder (MASTER cradle)
- Non-motorized SLAVE cradle is driven by the adjacent girder



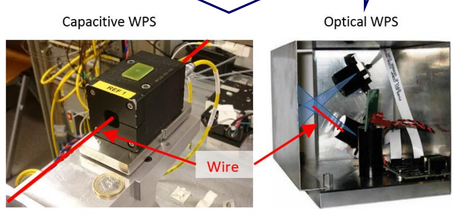
MASTER cradles

Only the MASTER cradle has an impact on the active pre-alignment process. The actuators control the X-Y position as well as the roll of a cradle, resulting in a 3 DOF mechanism



Articulation point

The SLAVE cradle is driven by the MASTER cradle thanks to a flexural ’Articulation point’.



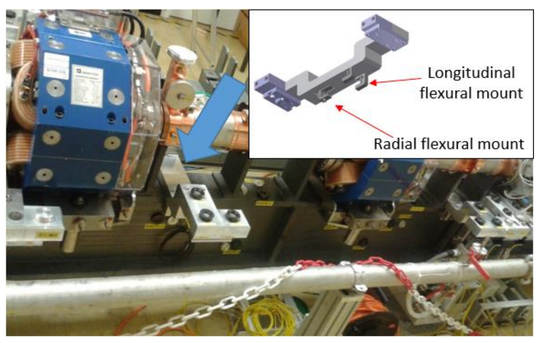
Sensors

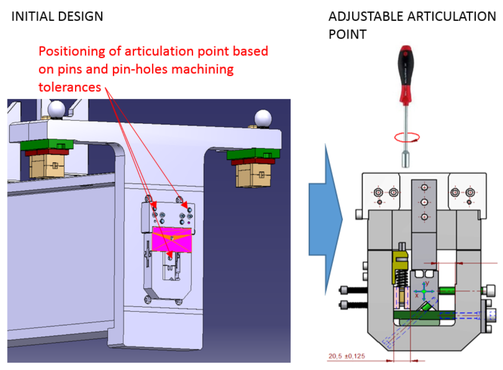
Wire Positioning Sensors (WPS) and inclinometers, gives the feedback data to compute the position of supporting structures

Mock-up validation and encountered issues

Cradle-girder material compatibility

The temperature variations caused cradle-girder misalignment due to their materials (Al, SiC) thermal expansion coefficients differences. A temporary solution of thermally stable artificial cradle was applied.





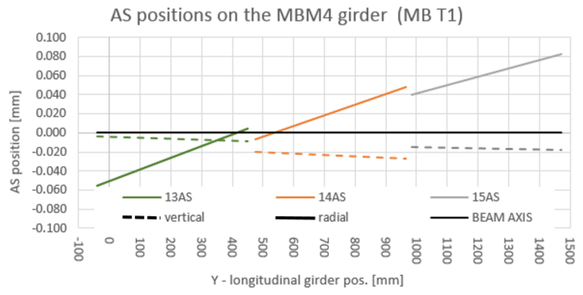
Adjustable articulation point

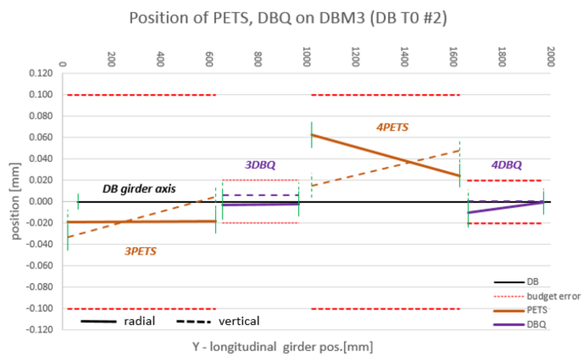
First generation of MASTER-SLAVE cradle flexural inter connection did not meet the alignment requirements. A new, adjustable solution was developed

Alignment of the components on the girder

The RF components should be machined in way to provide their proper alignment on the girder V-supports

Power Extraction and Transfer Structures (PETS) positions always in tolerance → maximum 80µm misalignment observed w.r.t. ±100 µm tolerance)

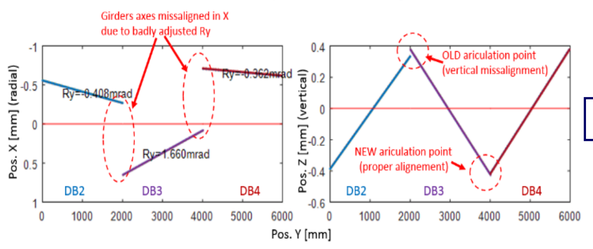


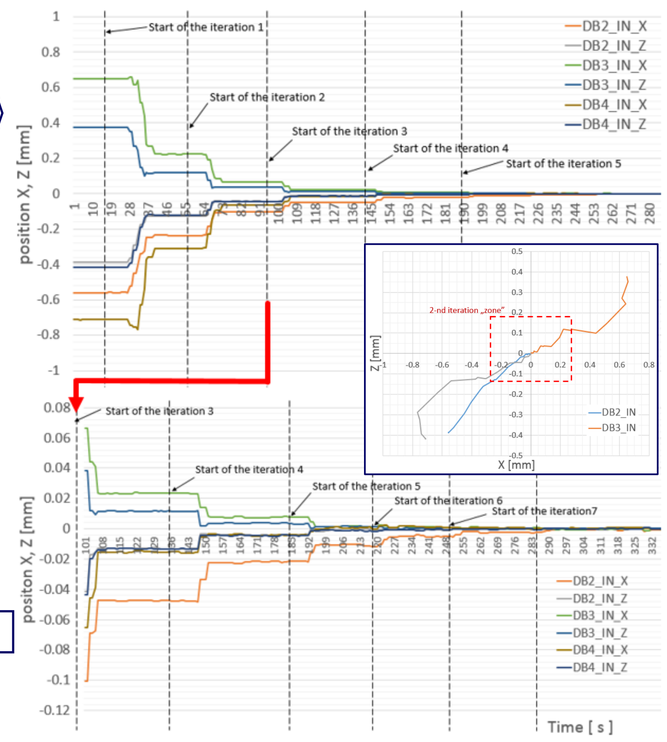


Accelearting Structures (AS) need to improve their production technology. In the best case, the AS misalignment w.r.t. V-support’s (girder) mean axis is 60 µm w.r.t. ± 14 µm tolerance

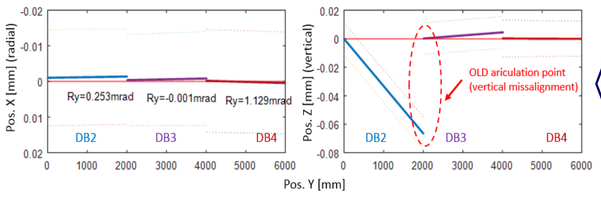
Active alignment tests

Tests were performed on the “snake”-structure of three Drive Beam girders DB2 - DB4. The girders were misaligned in random directions with a maximum position error of 0.3 – 0.8mm. The roll (Ry) of the girders was set in range of -0.4 mrad to 1.6 mrad



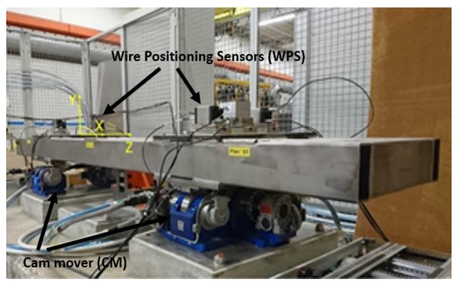


For the tested regulation algorithm, the 10 µm tolerance zone was reached after 4 iterations, showing perfect con-vergence. The typical stabilizing time of position for single iteration was ~10s allowing for big errors corrections even within 1 minute.



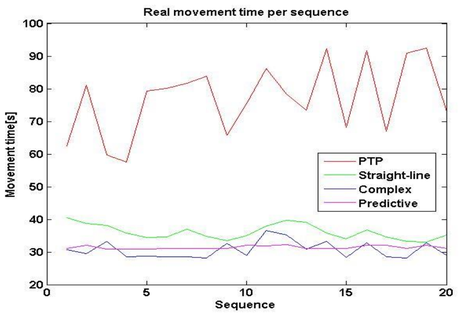
The trajectory of MASTER cradles was slightly non linear for the first algorithm iteration due to big actuators shifts requested.

Case of Main Beam Quadrupole Alignment



The Main Beam Quadrupole (MBQ) alignment control algorithm tests were performed on a parallel test stand at CERN. The mock-up including the girder, mounted on CAM movers (CM) and equipped in WPS sensors was used.

All positioning algorithms managed to reach all sequence targets within tolerances. The movement time of Syn-chronous PTP algorithm (60 – 90s) is significantly longer than that of the others (30 – 40s)



Conclusions

Closed loop adjustment of “snake”-like girders string shows that absolute active alignment of supporting structures is feasible within the specified accuracy. Concerning the alignment of MBQ, the CLIC positioning requirements can be met in one movement by using feedback directly from alignment sensors.
There are still issues linked with RF structures alignment on the girders