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A universal adjustment platform to position the High Luminosity LHC components according to 6 degrees of freedom

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Abstract
A universal adjustment platform has been developed to position accelerator components with a weight below 2 t . It will control 6 degrees of freedom with a displacement resolution of each axis within 10 µm. The objective of such a platform is to simplify the process of adjustment that can be fastidious and time-consuming. For this Stewart-based platform, the kinematics has been optimized in such a way that all the displacement axes are independent, leading to an intuitive adjustment. All the adjustment knobs are located on the same side, with a possibility to plug temporary motors or even permanently installed motors. Two models of platform have been developed for components lighter than 300 kg or heavier - between 300 and 2000 kg. The two prototypes are presented with a focus on the results of the validation tests.

Large scale metrology, frequency scanning interferometry, internal monitoring, cryogenic temperature

1. Introduction

Since years, the accelerator surveyors have been facing the difficulties to perform a fast and safe alignment of components located in radioactive areas. Usually, the positioning of accelerators' devices, such as magnets, accelerating cavities and collimators, has to be performed in an fast and ergonomic way to decrease the intervention time, directly linked with the ionizing dose received by the personnel. Morover, each of the components has a specific positioning requirements, making the design of its alignment system more complex. Currently the engineers consider two solutions for the positioning system design. In high radiation zones, where remote adjustment is required, motorized solutions are proposed, using precise, but expensive automatic positioning stages and platforms. In the accelerator zones where the access is not limited, simple manual adjustment mechanisms, using regulating screws and shims are chosen, but sometimes their operation is very time-consuming.
Considering the two adjustment approaches mentioned above and the fact that the alignment requirements become tighter and tigher, a study has been launched at CERN in 2012 to propose a fast and user-friendly positioning solution. A first prototype was proposed for the CLIC Drive Beam Quadrupole, where a modified "Stewart platform" was used to provide an intuitive and an ergonomic adjustment of quadrupoles [1]. Following the CLIC platform, the study was then focused on adjustment mechanics and cost optimization for HL-LHC [2] components alignment, leading to the design of an universal adjustment support using modular standardised mechanical components [3]. Such an approach allowed the combination of key factors: an easy and ergonomic operation (intuitive adjustment, knobs on same side); a precise and long range adjustment of the supported components and a decrease of the overall cost of alignment installations through the standardization of the adjustment platforms' sub-components.

2. Universal Adjustment Platform concept

The Universal Adjustment Platform (UAP) concept targets to provide the methodology to design the adjustment platforms for lightweight accelerator components, with the use of a set of standardized joints and adjustment jigs [3]. Figure 1 shows the conceptual schematic of the typical UAP mechanics and groups all properties of the system.

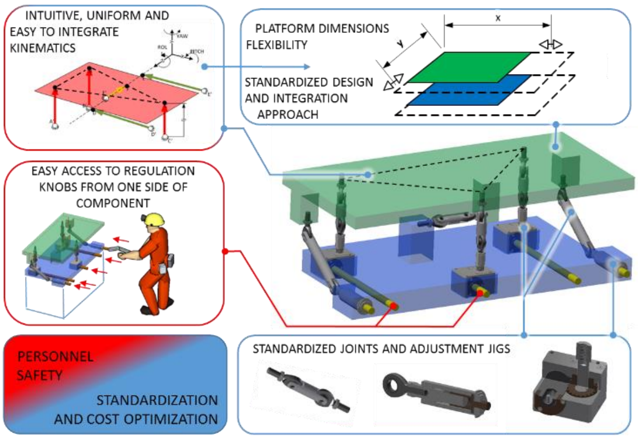

Figure 1. UAP concept properties schematic

The UAP standardized components will be produced in big series, to decrease the overall cost of the system. The equipment responsible (the user of the specific platform based on UAP) will be in charge to design and integrate the platform components and to scale its size to the dimensions of the component installed on the upper plate (according to the UAP design guidelines provided within the project frameworks). Two main types of UAP were defined, considering possible use cases:

- Small UAP for components weighting between 100 and 300 kg;
- Big UAP – for heavier equipment, weighting above 300 kg up to 2 t (collimators, small masks).

The design methodology for the small and big UAP will be the same; however each of these platforms will need different family of joints/adjustment jigs to fulfil the maximum load requirements. The detailed UAP description can be found in [3].

3. CERN UAP prototypes

The first small UAP prototype was designed in 2018 with the objective to provide an adjustment accuracy of ±50 µm. In parallel to the platform design, pre-series of standardized adjustment jigs were manufactured and tested under radiation, showing a proper behaviour up to 3 MGy irradiation.

The platform prototype was initially tested at CERN, beginning of 2019, demonstrating the expected functionalities of the platform and confirming that the design assumptions were correct. The adjustment ergonomics and precision in manual operation fulfilled the requirements, neverthless some stability issues were detected after adjustment, forcing a re-design of the standardized components to reduce the backlash of jigs and joints [3]. Following the first prototype results, the necessary modifications were deployed in the second prototype (Figure 2). The main changes were: replacing the standardized spherical joints with custom made "zero" backlash joints; tightening the backlash in the jigs and upgrading the stiffness of the TOP plate.

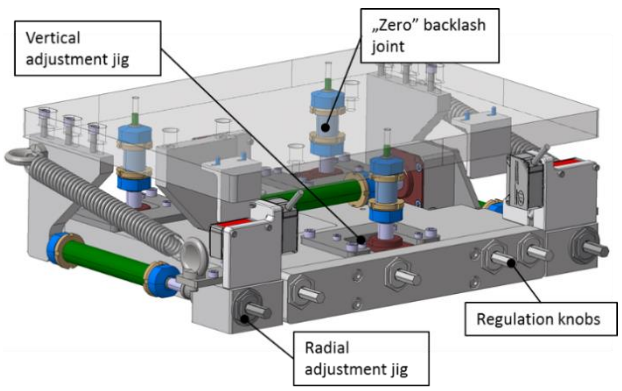

Figure 2. Small UAP prototype – version with "zero" backlash joints and upgraded jigs

4. Test results

The test of the upgraded small UAP, equipped with "zero" backlash joints was performed in April 2019. The same set of the tests was carried out (than for the January 2019 test campaign) and the results were compared to the initial ones:

- The directional backlash (platform without TOP plate load) was reduced from 90 µm to 5 - 10 µm;
- The stiffness in vertical increased to 0.3 µm/kg, from the previous value of 0.8 µm/kg;
- The lateral stiffness (platform loaded 0-300 N horizontally) decreased typically to 2 - 3 µm/kg, compared to the previously measured 4 - 5 µm/kg;
- The torque on adjustment knobs with 200 kg load on the platform remained at the level of 0.25 – 2 Nm;
- Long term stability tests (under nominal load) were performed: several cycles of adjustment were followed by several days of platform stability measurements: no drift of position was detected;
- The stability of position after transient lateral force of 20 - 50 kg was checked. This test showed that temporary position disorders do not affect the position stability more than 25 µm, after releasing the disturbing force (Fig.3);
- The platform adjustment accuracy was below ±20 µm for a two iterations approach (one initial and one corrective adjustment step only), compared to ±50 µm from the initial tests.

The above test results showed that the upgrades introduced to the small UAP design fulfilled the project requirements.

Figure 3. Stability tests results

5. Big UAP prototype design

The success of the tests on the small UAP opened the path to the design of the big UAP, which is a heavier equipment (300 – 2000 kg) carrier version of platform. The project started in August 2019 with the design of jigs capable to support 2 t load installed on the UAP. The new version of jigs, with a nominal load of 15 kN for the vertical one and 2 kN for the radial one were designed. "Zero" backlash joints were also scaled to bigger loads. The big UAP prototype was designed to support a HL-LHC collimator, as a real example of carried equipment.

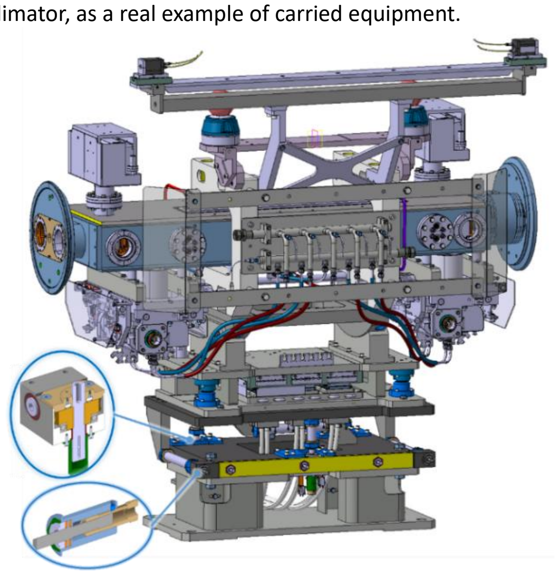

Figure 4. Big UAP prototype – adopted as collimator support

6. Conclusions

The test campaigns of the initial and the upgraded prototype of small UAP demonstrated that the platform design fullfills the project requirements. All parameters were assessed as satisfactory, hence the design of the big UAP version could start. The next step in the UAP standardization will be the test of the collimator platform.

References

[1] M. Sosin et.al., "Design and Study on a 5 Degree-of-freedom Adjustment Platform for CLIC Drive Beam Quadrupoles", *5th International Particle Accelerator Conference*, Dresden, Germany, Jun 2014

[2] High-Luminosity Large Hadron Collider (HL-LHC). Preliminary Design Report, edited by G. Apollinari, I. Bejar Alonso, O. Brüning, M. Lamont, L. Rossi, CERN-2015-005, CERN, Geneva, 2015

[3] M.Sosin et.al. "Design and Study of a 6 Degree-of-Freedom Universal Adjustment Platform for HL-LHC Components, *International Particle Accelerator Conference*, Melbourne, Australia, May 2019