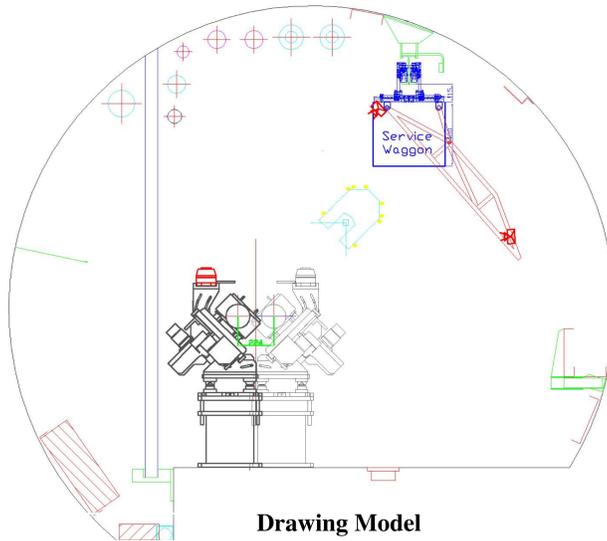


ABSTRACT

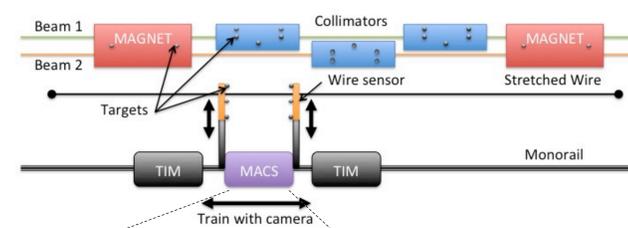
Periodically the alignment of LHC collimators needs to be verified. Access for personnel is limited due to the level of radiation close to the collimators. The required measurement precision must be comparable to the other equipment in the LHC tunnel, meaning 0.15 mm in a sliding window of 200 m. Hence conventional measurements take 4 days for a team of 3 people. This presentation covers the design, development and commissioning of a remotely controlled system able to perform the same measurements in 1 h with one operator. The system integrates a variety of industrial devices ranging from sensors measuring position and inclination to video cameras, all linked with a PXI system running LabVIEW. The control of the motors is done through a PLC based system. The overall performance and user experience are reported.

Control of the collimator alignment

The beam cleaning insertions in points 3 and 7 of the LHC will become one of the most radioactive zones in the LHC. A remotely controlled train in the tunnel does the control of the elements' position with the operators outside of the tunnel. This train is mounted on the existing monorail in the LHC tunnel.



Drawing Model

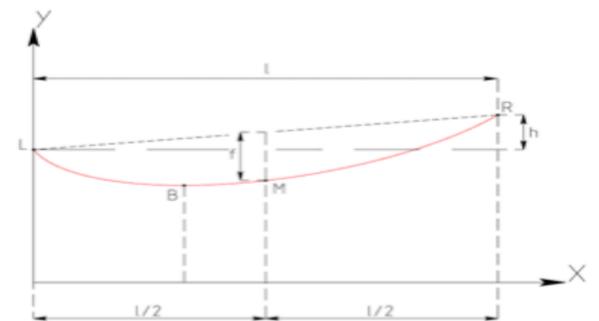


Train concept

A photogrammetric system was developed to measure the relative coordinates of the collimator elements with respect to the surrounding reference magnets. In order to cover the whole zone, 5 overlapping and fixed wires are used to connect the different acquisition volumes of the camera system.



The theoretical wire sagitta is calculated using the information of the current longitudinal position with respect to the corresponding wire extremities and the parameters of the concerned wire.



Calculations

After the acquisition, the CERN SU software for transformations called Chaba is used in order to transform the arm systems of both sensors into the photogrammetric system. The sagitta and slope of the wire are corrected to obtain all points in a coordinate system properly aligned with the wire and the local vertical. These coordinates are then transformed into horizontal wire offsets and height differences, which can be treated in the standard way using the "CERN least squares compensation program" (LGC++)

Results

In January 2012, a measurement campaign has been done in situ on the LHC collimators at point 7 to validate the entire system and check the results. 26 reference magnets and 35 collimators have been measured over 500m. A couple of collimators could not be measured due to communication problems. The collimators are measured within one day spending a couple of hours for the installation in the tunnel and the rest of the time at the surface. Classical methods, such as direct leveling and stretch wire, takes 4 days for 3 people being all the time in the tunnel.

The repeatability of the measurement is less than 60 μm in altimetry and planimetry. Compared with classical measurements, the train measurements are within 0.22mm RMS. One has to be aware that the accuracy of the classical measurements is already in this range, so the comparison is within the measurement noise.

CONCLUSIONS

The entire system has proven to be working fine saving time and giving excellent results. Each sensor worked fine and with the expected accuracy range. The PXI crate met all the requirements for the power consumption as well as CPU availability. Choosing LabVIEW made it easy to develop specific drivers for each instrument and gather all the information in a manageable format. The PXI is now running Windows for compatibility reason with the camera software as well as the specialised application from survey team. In the future, the PXI crate will run hypervisor with Windows on 2 cores and PharLap on 2 other cores. This modification will provide an even higher reliability of the entire system.

To be able to reliably handle the instruments control, the online analysis and the communication to the surface, a dedicated LabVIEW application, called Multiple Alignment Control System (MACS), has been developed using a PXI based platform.

