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Data Acquisition and Management in the Calibration Processes of the CMS Barrel Muon Alignment System

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The CMS Barrel Muon Alignment System is composed of a series of elements - each of large quantity - to be calibrated individually and together after assembly. This requires an approach based on modular control and data acquisition hardware and software including data validation features during data taking. The measured data of all calibration steps (including full images) are stored in a database together with the final results obtained after the processing and evaluation of raw data. A dynamic WEB-based reporting tool makes it possible to follow the status of calibration and assembly, and provides an easy search for any data. In the paper this approach is shown on the example of the two main element groups.

Summary

The CMS Barrel Muon Alignment System is composed of a series of opto-mechanical and opto-electronical elements. These elements can be arranged into two main groups, the chambers and MABs (Module for Alignment of the Barrel). The starting element of the chamber group is the light source (called “fork”) containing 10 LED light sources. The forks (1000 pieces altogether) are mounted on the barrel muon chambers (4 forks on each of the 250 chambers). The chambers are mounted on the CMS detector. The starting element of the MAB group is a 2D video-sensor that is - together with an imaging lens - enclosed in a camera-box. The camera-boxes (600 pieces in total) are mounted on the MABs (large-scale rigid carbon-fibre mechanical support structures, 36 pieces in total). The MABs are mounted on the CMS detector in a way that the camera-boxes can observe the LEDs on the forks. The images captured by the video sensors serve as an input to reconstruct the locations of the chambers inside CMS with submillimeter accuracy.

To achieve this goal the position of the elements within the system must be known with a precision beyond the manufacturing accuracy, ie:
- the location of the centre-of-mass of the emitted light spot of the LEDs on the forks with <10 micrometer;
- the location of the forks on the chambers with <70 micrometer
- the homogeneity, sensitivity and linearity of the video-sensors with <1%
- the lens-sensor distance in the camera-box with <10 micrometer and the perpendicularity of the sensor to the optical axis of the box with <3 millirad
- the location of the camera-boxes on the MABs with <50 micrometer and 50 microrad.

Therefore each piece of all element types have to be identified, calibrated and the position of each embedded element on the enveloping object must be known and followed.
Given the large number of elements and the complexity of the system, the data handling procedures of the calibration and assembly were automated as much as possible.

Five calibration facilities have been built to calibrate the forks, the chambers, the sensors, the camera-boxes and the MABs. They are very different in size and complexity but similar in nature: in all of them LED-type light sources have to be switched on and off and driven with given current and their images have to be captured by camera-boxes. These functions are complemented -depending on the task- by other control and DAQ functions like 2D-motion table control, video-multiplexing or environmental (temperature and humidity) measurements. Therefore all the facilities are also similar from control, data acquisition and data handling point of view.

The core hardware elements of the control and data acquisition system are the microcontroller-based modular units that - together with the control software - can easily be adapted to any particular calibration step. As the primary result of all the measurements are either full video-images or light spots, the image processing and transfer solutions can be reused at each calibration step.

The intermediate and final calibration values are stored in a relational database. Each step of the calibration procedure heavily relies on the results obtained in the previous steps, so the online query and update features offered by the database system are vital to our design. A dynamic WEB-based reporting tool makes it possible to follow the status of calibration and assembly and to search for any data in an easy way without direct database-operations. In the paper these points are discussed in detail.

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