Contribution ID: **65** Type: **Poster**

Completion of the CMS Muon Barrel Alignment System and its integration into the CMS detector environment.

Thursday 18 September 2008 16:15 (20 minutes)

During the past years our group has built, calibrated, and finally installed all the components of the Muon Barrel Alignment System of the CMS experiment. This paper covers the results of the hardware commissioning, the full system setup and the connection to the CMS Detector Control System (DCS). The step-by-step operation of the system is discussed: from collecting the analog video signals and preprocessing the observed LED images, through to controlling the front-end PCs and forming the measurement results for the CMS DCS. The first measurement results and the initial experiences of the communication with the DCS are also discussed.

Summary

Although all the elements of the CMS Muon Barrel Alignment System have been carefully tested during the assembly and calibration, it is mandatory to perform the full commissioning of the whole system. The commissioning consists of two steps: the functionality test, and the initial start-up measurement. During the functionality test, all the parts are checked using the full chain of installed elements including the cabling, Ethernet network, main control, DAQ PC and its software, and the low voltage units. After the functionality test, all the optical connections (i.e. each light source detected by the corresponding video-sensor) have to be measured. This measurement serves as an initial input to build up the control program based on the expected images and exclude the invisible connections (e.g. out of the visibility due to installation tolerances or objects blocking the light). The summary of the results of the commissioning is also given in the paper. Analog signals from the cameras are processed by a PC104-type computer, called the BoardPC. Each alignment module (MAB) has its own BoardPC, making 36 pieces altogether. Therefore, a highly parallelized computing network is formed. BoardPCs are equipped with a video digitizing card and a so called Custom Board, which was designed and produced by ATOMKI, Debrecen, Hungary. Each Custom Board contains a 24-way video multiplexer, several current generators for LED sources, and read-out electronics for digital temperature and relative humidity meters installed on the MABs. Drive units for these meters are also housed on the Custom Boards. Board PCs boot from the local network server, but after boot-up they act as autonomous machines and are able to calculate LED centroids or to submit raw images observed by their cameras.
An additional computer acts as a boot, DHCP, and file system server. Furthermore, this machine coordinates the work of the BoardPCs and connects to the CMS online computing network.
On this central controller machine, Java based software is responsible for the optimized measurement sequence, where the order of the individual centroid measurements are decided using applicable rules, rather than on a predefined sequence.

This Measurement Control software communicates with the supervisor panel via a custom protocol. This panel is written in a process monitoring language, used industry-wide, called PVSS. It gives information about the measurement and the actual status of the system. Alignment personnel can send commands through this panel. The other main part in our PVSS project is the Low Voltage control. The subsystem uses Caen power supply modules. This hardware communicates with PVSS via the OPC industrial standard. The supervisor panel allows alignment experts to set the low voltage modules of the system. The whole subsystem will use a finite state machine model, and will therefore fully comply with the experiment's guidelines. Due to this, the Muon Barrel Alignment System can be fully integrated into the CMS Detector Control System. It means that our subsystem can provide states and alarms upward to the CMS Detector Control System, and is able to accept commands from the Run Control.

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Session Classification: POSTERS SESSION