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Quality Control of the CMS Tracker and ECAL Installed Optical Cabling

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The readout and control optical links, developed for the CMS Tracker and ECAL at CERN, are approaching the final phase of the integration process at LHC Point 5. The individual component parts have been successfully integrated and connected at the innermost distributed patch-panels. Currently, efforts are concentrated on the multi-ribbon optical cables installation and connection to ribbon cables at the dense, in-line optical patch-panel inside CMS and to the racks at the backend patch-panel in the service cavern. Within the quality assurance programme, the quality control activities can give an online feedback during cable installation and provide an acceptance of the installed fibres. The final optical link lengths can also be measured as a precise input to the Tracker synchronization procedures. The recent integration experience and the quality control test system based on an Optical Time-Domain Reflectometer are described.

Summary

The CMS detector is currently undergoing its final integration phase at CERN LHC Point 5. It includes the largest and densest fibre optic system in the world of its type. The inner Silicon Strip Tracker is read out and controlled by 43000 point-to-point optical links routed to three different patch panels: an inner (distributed) one, a dense intermediate (in-line) and a (distributed) backend patch panel. Similar optical links are used in the ECAL, preshower and pixels sub-detectors (about 15000 in total), as well as a smaller number links for RPC, BCM/BLT and TOTEM.

The integration of the optical components inside the sub-detectors has been completed and various tests have been made to check the functionality and the quality of the optical connections for the Tracker. In the Tracker case, the inner patch panel is now fully connected, the Tracker has been closed and the optical (12-fibre) fanouts have been carefully routed to the edge of the structure and there arranged, ready to be connected to the intermediate patch panel (PP1).

From PP1, situated in the central CMS barrel wheel (YB0), about 560 multi-ribbon (96-fibre) cables (120 for ECAL barrel) have to be connected and routed between the experimental (UXC55) and counting room (USC55) caverns. During the whole process, acceptance and quality tests have to be performed in order to validate the cable installation, give an assessment on the quality of the connections and measure the full optical link lengths, which are needed later for the synchronization of the Tracker.

In order to do this, a specific quality control procedure was defined, as part of the quality assurance procedure, and a test setup, based on a photon-counting optical time-domain reflectometer (OTDR), was developed.

The basic test principles of the instrument consist of injecting light of a certain wavelength and with a certain pulse repetition rate into the fibre to be tested, measuring the back reflection peaks. Reflections are typically due to a connection, a termination or a break in the fibre. Under certain conditions, also an estimation of the light-loss in the fibre and connection is possible.

During the trunk cable installation (pre-cabling), the time is an issue and the test system must be efficient and fast enough to allow the operator to work in the shadow of the ongoing activities. A novel method using the high resolution OTDR combined with a customized optical splitter module, with 12 parallel fibre channels of different lengths, allows separating the reflected signals coming from 12 fibre channels simultaneously.

Over 100 multi-ribbon cables have been installed and connected for testing the Tracker at CERN TIF. All of them were tested before and many (80%) after the connection, using the OTDR setup, with encouraging results: no cable was broken or damaged during the installation and, in all cases, it was possible to measure the lengths with a precision of 10cm or better.

Even though the test setup was developed basing on the Tracker cables configuration, it is flexible enough to be used also on the other subsystems as well as debugging tool during the Tracker integration activities.

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