CMS Tracker, ECAL and Pixel Optical Cabling: Installation and Performance verification

Thursday 18 September 2008 16:15 (20 minutes)

The installation of over 55000 optical links for the readout and control of the CMS Tracker, ECAL and Pixel detectors is now completed at CERN LHC Point 5. During the 2007 cabling campaign 672 optical cables that span between the experimental and service caverns were installed and tested. The connection to the optical, highly dense, patch-panels inside CMS followed in the first months of 2008. Within the quality control programme, an extensive test campaign was carried out in parallel in order to validate the cabling and connection process and feedback any improvements. In the end 99% of the failures were recovered and the Tracker, in particular, resulted with 0.13% of not working channels. For the Tracker, a verification of the optical link performance followed once the detector was powered-up and commissioned.

Summary

The CMS optical cabling system for the readout and control of the ECAL Barrel, Tracker and Pixel subdetectors comprises 55000 single pigtailed fibres, 4500 12-fiber fanouts and 672 multi-ribbon trunk cables (96 fibres each). The pigtails (no longer accessible during the cabling operations) are connected to the fanouts inside the sub-detector volume. From the edge of each sub-detector, the fanout tails have to reach the in-line patch panel (PP1, inside the CMS cryostat) where they connect to the cables.

In a 6 week-long cabling campaign that started in October 2007 the pre-connectorized cables were pulled, laid and fixed one by one along the edges of CMS from PP1 to the back-end racks in the adjacent service cavern (about 60m distant). The procedure followed was the same for all the sub-detectors starting from the ECAL Barrel (108 cables distributed in 36 patch-panels) and continuing with the Tracker and Pixel (534 cables in 32 PP1).

During the installation the cables were systematically tested with a photon-counting Optical Time-Domain Reflectometer (OTDR) in order to verify the mechanical integrity of the fibres. In addition feedback was given to the cabling crews laying the cable in case any of the problems observed could be corrected by changing the cabling procedure.

It was important to maintain the testing-time to a minimum to ensure testing kept pace with the cabling to give the possibility to replace or repair a cable before it was no longer accessible. Thus the OTDR was equipped with a custom-developed optical splitter reducing the time of testing from 1 hour/cable (1 fibre at a time) to 20 min/cable (12 fibres at time).

In December 2007, after the cabling, the ECAL Barrel fanouts were connected at the patch-panels and the system measured again with the OTDR (test of the "full-links") before the final connection at the back-end. A similar procedure was followed for the Tracker and Pixel which also required the fanouts to be routed along the 4m cable channel from the bulkhead to the patch-panels (for the Pixel a fanout extension was also required).

The quality control protocol, extensively practiced in the past years, required that 100% of the links be checked after the connection at PP1 to validate the quality of the fibre routing and connections as well as, in the Tracker case, to measure the overall optical link lengths needed later for synchronization. As an example, for the Tracker (completed in March 2008) 91 interventions were required to re-clean/re-mate defective connections and 20 to repair (with a fusion splice) broken ribbons. In the end only 12 channels were lost (non repairable) proving not only the good quality of the components but also the validity and robustness of the quality assurance programme.

For the Tracker, the procedure also includes a verification of the optical link performance when the system is powered on. In the initial phase, the cabling functionality is checked and this may require some troubleshooting, especially at the back-end connections since they were not checked in the previous tests. Subsequently the link calibration parameters (e.g. working point, gain) are measured also at different temperatures. The measurements of gain in particular can be compared with the expected values derived from the production tests in order to show that the link specifications have been met.

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Session Classification: POSTERS SESSION