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Integration of the CMS Tracker Optical Links

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Analogue and digital optical links developed at CERN are currently being integrated into the CMS Tracker in the magnet-test/cosmic challenge (MTCC), Tracker Integration Facility (TIF) and at the experiment site in Point 5. Similar activities with the same or very similar optical links are also underway for CMS ECAL as well as other CMS detector systems. Recent hardware developments include the dense, in-line optical patch-panels as well as back-end patch-panels. Quality assurance and quality control procedures have been developed and practiced, including the cabling and connection procedure, acceptance tests for the cabling and connections, and tests of final system performance, in particular the analogue optical link gain and dynamic range. A summary of the progress of the integration is given along with the results to date from the various acceptance and performance tests in the MTCC and TIF.

Summary

The CMS Tracker uses analogue optical links (˜40000 channels) and digital optical links (˜3000 channels) for analogue readout and digital control respectively. The optical links are typically 60m long between the Tracker in the CMS experimental cavern and the counting room in the adjacent cavern. The optical links are based on commercial off-the-shelf parts including 1310nm edge-emitting lasers, InGaAs photodiodes and single-mode fibre-optic cables. The active components are integrated onto compact, rad-hard opto-hybrids at the front-end and into commercial modules at the back-end. The fibre-plant includes single-fibre, 12-way ribbon and 8x12 multi-ribbon cables. There are three patch-panels for the optical fibre connections: one at the front-end, close to the optohybrids, a second very dense, in-line patch-panel within the CMS magnet coil, and the final connection point at the back-end modules.

Recent hardware development has focused on mechanical parts for the in-line and back-end patch panels as well as management of the cable routing on the racks and the storage of excess cable lengths. The in-line patch-panel (optical-PP1) consists of a box in each of 32 phi-sectors of CMS that hold optical cables. Each of these optical-PP1 boxes has 4 removable cassettes that together manage the connections for up to 20 multi-ribbon cables per sector, i.e. up to 1920 optical fibre channels per optical-PP1 box. The envelope of the optical-PP1 volume is approximately (in mm units) 1000x160x80 (length x height x width) and the patch-panel design includes storage of excess lengths of ribbon-cable as well as strain relief elements. Prototypes have been produced and tested in the lab and one optical-PP1 is currently being used in the CMS magnet-test/cosmic challenge (MTCC). The production of the final cassettes will be done in Q2 of 2006.

Concerning the other components of the optical links, all the optical link front-end parts have been produced and are now being integrated into the Tracker front-end detector systems. All the back-end optical receiver and transceiver modules have been produced and integrated onto VME cards or their mezzanine boards. There has been very good quality of integration and system performance with few breakages or failures. The quality control tests of link performance after integration into the Tracker sub-detectors will be described and a summary of the results given, focusing on the analogue optical link gain and dynamic range.

Preparations are beginning for the final optical cabling of the Tracker in CMS at LHC Point 5, which will occur over several months in early 2007. A cabling procedure has been developed and is being practiced in the MTCC and TIF. The final trunk cabling will involve laying and fixing of 560 multi-ribbon cables onto the CMS detector from the in-line patch panel (PP1) out to the balcony on the cavern

wall, followed by pulling and routing through the passage into the counting room cavern and onto the final destination rack and back-end patch panel. There will be about 5m slack per cable that will be stored beneath the racks in the false-floor in the couting room. After the Tracker is installed in the cavern, the remaining cabling can be made from the Tracker to the inline-patch panel, involving approximately 4000 12-way fibre ribbons.

Extensive QC (acceptance) tests of the cabling and connections are foreseen and these will be presented. The tests include visual inspection of the cabling, connections, barcode controls, plus measurement of the optical performance in terms of light-loss in the cables and connectors. Time-pressure is expected and these tests of the cables and connectors will be done in parallel with the installation. Either a simple light-source/receiver (for a basic test of the trunk cables only) or a specialized instrument such as an optical time domain reflectometer (OTDR) will be used. The OTDR can be used for testing either the trunk cables alone or for testing the full optical link system. As well as detecting broken optical fibre channels or poorly mated optical connections, the OTDR provides also a precise measurement of the cable lengths in the system which are needed for synchronization of the Tracker.

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