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Commissioning the CMS silicon strip tracker

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The CMS silicon strip tracker is the largest device of its type ever built for the detection of charge particles produced in beam-beam collisions. There are 24244 single-sided micro-strip sensors covering an active area of over 200 square meters and nearly ten millions of readout channels. The sub-detector was installed inside CMS in December 2007. We report on detector performance studies from the commissioning phase, when the complete readout system was calibrated and synchronized for the first time, and on experiences from global cosmic runs with other sub-detectors of the CMS experiment.

Summary

The CMS silicon strip tracker (SST) is unprecedented in terms of its size and complexity, providing a sensitive area of over 200 square meters and comprising ten million readout channels. The readout system is based around a 128-channel custom front-end ASIC known as the APV25 chip, an analogue optical link system and an off-detector Front-End Driver (FED) VME board that uses FPGA technology for much of its processing capabilities. 76000 APV25 chips sample, amplify, buffer and process signals from silicon strip sensors mounted on 15000 front-end modules at the LHC collision frequency of 40 MHz. On receipt of a Level-1 trigger, the APV25 chips transmit analogue pulse height data to 440 FEDs, which digitize, zero-suppress and format the data. The resulting event fragments are then transmitted to the CMS online computing farm, which hosts a software-based second-level trigger system.

Commissioning such a large-scale readout system requires sophisticated, automated procedures to bring the detector into an operational state that is suitable for physics data-taking. Examples of such procedures are: detection of the readout system connectivity and partitioning; internal synchronization of the front-end system (with a precision at the level of a nanosecond); latency scans to synchronize to the passage of charged-particle products of beam-beam collisions; pulse shape tuning of the APV25 amplification stages to achieve optimal signal-to-noise and minimize pile-up; and the determination of calibration constants used by the FEDs in order to zero-suppress the data. These procedures, amongst others, are used to tune, measure and monitor the operational performance of the sub-detector.

The strip tracker was installed inside the CMS experiment at Point 5 on the LHC accelerator ring in December 2007. Presently, "checkout"of the ˜350 control rings within the strip tracker is underway, which focuses on identifying possible problems with the connectivity and services of the control, readout, monitoring and power supply systems.* Once checkout is complete, the strip tracker will be commissioned as a complete entity and operated with the other sub-detectors of CMS during global cosmic runs. No results are yet available from commissioning at Point 5, but large-scale tests (comprising data-taking with 1.7 million channels of the completed strip tracker system) during the integration phase in the summer of 2007 demonstrated the high-quality construction of the strip tracker and excellent performance, with a dead/noisy channel count at the per mille level and a noise performance that compares favourably with the design specification.

We will report on results and experiences from the commissioning phase and global operations with the CMS experiment during cosmic runs, focusing on the performance aspects of the strip tracker readout system. First beam-beam collisions are expected in the latter part of 2008.

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