Contribution ID: **13** Type: **Oral**

Quality Control Considerations for the Development of the Front End Hybrid Circuits for the CMS Outer Tracker Upgrade

Tuesday 12 September 2017 08:55 (25 minutes)

The upgrade of the CMS Outer Tracker for the HL-LHC requires the design of new double-sensor modules. They contain two high-density front end hybrid circuits, equipped with flip-chip ASICs, passives and mechanical structures. First prototype hybrids in a close-to-final form have been received from three manufacturers. To qualify these hybrids a test setup was built, which emulates future tracker temperature and humidity conditions, provides temporary interconnection, and implements testing features. The system was automated to minimize the testing time in view for the production phase. Failure modes, deliberately implemented in the produced hybrids, provided feedback on the system's effectiveness.

Summary

The second phase of the LHC operation imposes demanding requirements on the particle detectors. The total dose of particle collisions will be raised by a factor of 10 beyond the original design value (from 300 to 3000 fb-1). The luminosity increase results in higher radiation and data rate. A complete replacement of the CMS Outer Tracker is foreseen to cope with these new constraints. Its design is optimized to provide the most useful and accurate information about the trajectories of the collision products, together with a reduction of the necessary data flow. To achieve these goals several features are implemented at the level of front end modules, such as lower mass, Level 1 track triggering functionality, data compression and a higher density of sensing channels.

The functional building blocks of the future CMS Outer Tracker structure are two types of double-sensor modules. Both types will be produced in different versions that vary in the distance between their sensor planes. Each module contains two high-density front end hybrid circuits. These hybrids host binary readout flip-chip ASICs, which are connected with silicon strip sensors. Additionally, each hybrid is equipped with auxiliary electronic components and mechanical reinforcement structures, which also serve as a cooling interface. In total ten different front end hybrid geometries are foreseen in the design of the future tracker. It is planned to produce as many as thirty thousand pieces.

The quality of delivered hybrids must be verified before they are used for module assembly. Testing is crucial in order to ensure a high yield of fully functioning modules during the production phase. Mechanical, electrical and functional test protocols are evolving to address possible failures affecting the hybrid's performance. In the life time of the new CMS Outer Tracker, the temperature in the tracking volume will be gradually decreased below -30℃. A low temperature setup was built to conduct tests in an environment representative of the tracker operating conditions, requiring a specifically designed testing infrastructure. The constructed device cools the hybrid directly via its thermal contacts while protecting it against the humidity condensation. A dedicated software was developed to provide an environment control feature integrated with functional test algorithms, both automated in order to minimize the time consumption in view for the usefulness and scalability during the mass-production.

The first prototype front end hybrid variant, which matches the desired, close-to-final geometry, has been produced in 2017. Batches of mechanically compliant pieces were received from three manufacturers. Each batch was made and assembled using a different process with a unique set of design constraints and achievable

product quality. Deliberately implemented failure modes and an on-board temperature monitoring were used to characterize the test system as well as the developed functional testing procedures. The performance results are presented in terms of the quality control effectiveness, time consumption and hybrid cooling properties. The conclusions drawn from this experience have guided the strategy of the quality verification for the mass production phase of front end hybrids for the CMS Outer Tracker upgrade.

Author: GADEK, Tomasz (CERN)

Co-authors: BLANCHOT, Georges (CERN); KOVACS, Mark Istvan (CERN); DE CLERCQ, Jarne Theo (Vrije Universiteit Brussel (BE)); LUETIC, Jelena (Universite Libre de Bruxelles (BE)); SCHNEIDER, Basil (Fermi National Accelerator Lab. (US)); HONMA, Alan (CERN); KOLIATOS, Alexandros (National Technical Univ. of Athens (GR))

Presenter: GADEK, Tomasz (CERN)

Session Classification: Production, Testing and Reliability

Track Classification: Production, Testing and Reliability