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Hybrids Acceptance Tools for the CMS Phase Two Tracker Upgrade

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Up to fifty thousand front-end and service hybrids are required for the CMS Tracker Phase Two Upgrade. These hybrids, which are built on carbon fibre stiffened circuits and contain several flip-chip ASICs, will be glued in module structures, making repairs almost impossible. Due to their complexity, testing within production is a very important aspect. A multiplexed testing infrastructure, based on custom crates and test cards will be presented. This testing hardware is supported by software tools to enable the exhaustive verification of hybrids at the manufacturing sites and for their acceptance within the collaboration.

Summary (500 words)

The Compact Muon Solenoid (CMS) Tracker Phase Two Upgrade for the High Luminosity Large Hadron Collider (HL-LHC) is based on two main types of modules, the strip-strip (2S) and the pixel-strip (PS). The 2S modules contain two parallel strip sensors of 10 × 10 cm2 and two front-end hybrids interconnected with a service hybrid. The PS modules contain a strip sensor and a macro pixelated strip sensor of 5 × 10 cm2 and two front-end hybrids interconnected with a power and a data service hybrid. These modules require state of the art High Density Interconnect (HDI) front-end hybrids assembled with fine pitch flip-chip front-end ASICs, connectors and passives. Ten different front-end hybrid variants and five additional service, power and readout hybrid variants are today completing their prototyping phase for the upgraded Tracker.

The complexity and difficulty of repair of these hybrid circuits requires them to be tested during production. Therefore, a test system has been developed to support the testing during production.

This test infrastructure is based on a 3U 19 inch sub-rack with custom developed multiplexer backplanes enabling the testing of twelve hybrid circuits in one crate. The backplanes are designed to multiplex high speed differential signals, USB, control lines and to distribute power. The backplane connects to a data acquisition FPGA, the FC7, which controls the multiplexer and processes the data. The FC7 is connected through Ethernet to a computer running the test.

To connect to the multiplexing rack, five plug-in test cards were developed, one to test each type of hybrid: the 2S Front-end hybrids, the 2S Service hybrids, the PS Front-end hybrids, the PS Readout hybrids and the PS Power hybrids. In order to avoid designing different plug-in cards for each hybrid type variant, they are mounted on interchangeable sockets and specific interconnection circuits are designed to connect them to the test cards. All the test cards have been prototyped and they were used to qualify all the received hybrids.

The Phase Two Acquisition and Control Framework developed by the Data Acquisition team served as baseline for the implementation of test procedures compatible with the test cards. The plug-in test cards are controlled through USB, using a custom driver. A supervising user interface able to control up to three crates identifies the installed test cards and the hybrids under test, loads the corresponding firmware in the backend card, executes the associated test procedures and archives the test results in a production database. The tool monitors the extraction of the tested hybrids and provides instructions to the operator to tag the hybrid as functional or non-functional. This tool ultimately enables the testing at contractor sites for the whole production and will maximize the yield of functionally tested hybrids. The same tool will be used for acceptance controls within the collaboration in order to guarantee the full functionality of hybrids delivered finally to the module assembly sites.

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