2S Module assembly and quality control for the CMS Phase-2 Tracker Upgrade

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In the context of the LHC transition towards the High-Luminosity LHC, the CMS detector is undergoing major upgrades of the different subdetectors. Within the CMS Phase-2 Upgrade, the current pixel and strip tracker will be completely replaced by a new tracker. It will consist of an inner tracker with pixel modules and an outer tracker with a combination of pixel-strip (PS) and strip-strip (2S) modules. Around 7680 2S and 5616 PS modules will be required for the outer tracker.

The assembly process is distributed along multiple assembly centers worldwide. RWTH Aachen University will build around 1000 2S modules. The main components of a 2S module are the two silicon strip sensors with 10.2 cm by 9.4cm in size, each of them with 2·1016 strips. The sensors are glued onto aluminium carbon fibre bridges with a spacing of 1.8mm or 4mm, with one sensor on top and one on the bottom. Electric isolation of the sensor HV is assured by Kapton strips. Two Front-end hybrids (FEH) containing the read-out electronics are glued from the left and right sides to the sensors, and the read-out channels are connected by wire bonds to the sensor strips. The Service Hybrid (SEH) is then connected to the FEHs and provides power to the module as well as data connectivity to the back-end systems. The module was designed to be integrated into the Level 1 trigger, this by using the stub mechanism based on correlated hits in the two sensors.

In order to ensure that the assembled modules are within all specifications and of good quality, several inspections and measurements are performed throughout the module assembly. This contains visual inspection of raw components, metrology measurements to check the dimensions and the sensor alignment of the bare module sandwich. Sensor quality is determined by IV measurements as well as HV stability measurements over time. The wirebonding process is closely monitored by many process parameters of the bonding machine and controlled by pull tests.

Modules are then tested in the Single Module Test Station. Module IV measurements are performed together with readout tests. These tests include noise measurements and validation of the electronic chain and chip communication.

Final modules are qualified for the detector in the 'Burn-in' setup, where thermal cyclings are performed, as the modules are operated in the detector at around $-35°C$. The official burn-in for modules assembled in Aachen is done at DESY. A similar setup, named Multi Module Cold Box (MMCB), is available in Aachen to test and cycle up to 4 modules in parallel at various temperatures. This setup allows to test the operation of the module in cold and after many temperature cycles to identify potential problems, like for example

wire bonds or connectors that lose contact or mechanical deformation that may lead to HV sparks or instabilities.

A software tool named POTATO is used to analyse and grade all module tests performed during the assembly and burn-in phases. Validation of these test results is needed to assign grades to the modules. These gradings are based on various electrical and readout parameters of the module and are used to filter out bad modules before integration.

The complete assembly process is tracked in several databases. A local database equipped with a web frontend is available in Aachen to record all details of the assembly process. Selected data is shared with the central CMS construction database, where the data from all assembly centers is made available and used to track the collaboration-wide module production and quality.

In this talk, I will present my work on the 2S module assembly and testing, as well as the contributions to the POTATO software and database project.