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Automation and Quality Control for CMS Outer Tracker Module Assembly at Fermilab's SiDet

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Abstract

Automation and quality control techniques for 2S and PS sensor modules for the CMS Outer Tracker for the HL-LHC era have been developed at the Silicon Detector facility at Fermilab. Examples include a laser scanning procedure to check manufacturing specifications for the 2S sensor modules, and an automated gluing process to accurately assemble PS sensor modules. Processes were verified and documented for the production stage of the Outer Tracker.

Overview

The Compact Muon Solenoid (CMS) Detector is one of the detectors in the Large Hadron Collider (LHC) at CERN. CMS around the path of the beam of the particle accelerator. It detects collisions of the particles as the beams cross through the detector. The innermost sub detector is called the Tracker and is highlighted in the image above. The Tracker measures the charged particle tracks. The LHC is undergoing upgrades that will increase the integrated luminosity from 1000 fb-1 to 3000 fb-1 and due to this CMS will have to upgraded as well.

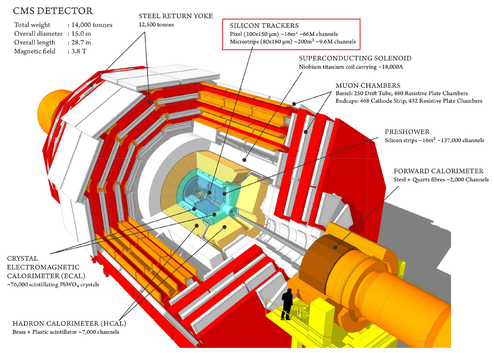

Figure 1: CMS Detector with Systems Labeled

Acknowledgements

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Outer Tracker Upgrade

The current Outer Trackers are going to be replaced with a system of two modules: the PS and 2S modules (Figure 2). These modules are named for the "pixel strip" and "strip strip" combination of sensors.The 2S and PS modules will form the basis of a momentum cut system (Figure 3). This system works because as a charged particle passes through the layers of the censors' models in the Tracker. As the momentum of the particle increases, the less it will bend. Due to this, in order to be accurate, the tolerances on the rotational misalignment between the top and bottom module are 400 μrad for 2S and 800 μrad for PS.

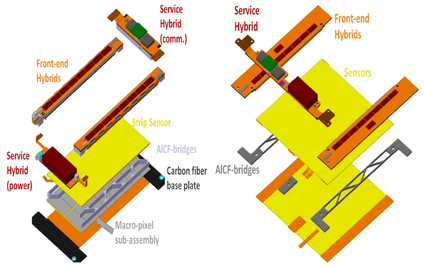

Figure 2: PS Module (Left), 2S Module (Right)

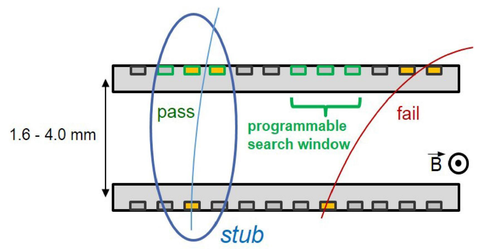

Figure 3: pT system

PS Automation

At Fermilab, the PS modules are assembled at SiDET by both technicians and automated gantries, like the LSTEP (Figure 4) which has a pickup tool, camera, and rotation stage. The first step places the top sensor (strip sensor) on the rotation stage, which is rotated to align it with the gantry axes. Next, the top sensor is picked up and pressed onto the spacers that are prepared with glue which dries for 20 minutes. The combination is then stamped on to a new glueing stage (Figure 5) which applies both a fast acting (allowing faster assembly) and a slow acting glue (for production bonding). After this the combination is pressed onto the bottom sensor (pixel sensor).This process was debugged and improved by building dummy modules made of glass slides, double sided tape, and plastic spacers.

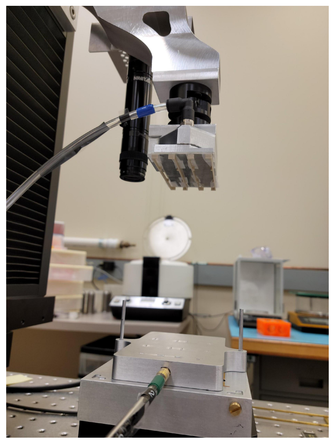

Figure 4: LSTEP gantry with dummy strip sensors and spacers

2S Automation

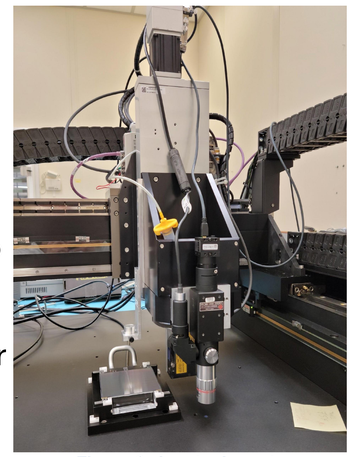

Figure 6: Aerotech gantry

An Aerotech AGS10000 gantry robot is used for the quality control and assembly of the 2S modules, where a LabView program uses the laser attachment on the gantry to measure the alignment of the top and bottom sensors. By having the laser scan the adjacent sides of the module and measure the distance to both sensors, we calculate the amount of rotation between the top and bottom sensors and the amount of offset in both the horizontal and vertical directions. The alignment measurement allows us to either accept the sensor or reject it. The LabView code also allows flexibility in location of the modules on the assembly stage.

Summary

Automated procedures were developed to assembly and do quality control measurements on the 2S and PS modules for the CMS Outer Tracker Upgrade.

References

"CMS Detector Graphic." CERN Accelerating Science, CERN, https://cms.cern/detector.

Dierlamm, Alexander. "The CMS Outer Tracker Upgrade for the HL-LHC." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment, vol. 924, 21 Apr. 2019, pp. 256–261.