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Beam Test Studies with the latest Silicon Sensor Module Prototypes for the CMS Phase-2 Outer Tracker

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The Large Hadron Collider (LHC) at CERN will be upgraded to the High-Luminosity LHC (HL-LHC) until 2029. In order to fully exploit the physics potential of the high luminosity era the experiments must undergo major upgrades. In the context of the upgrade of the Compact Muon Solenoid (CMS) Experiment the silicon tracker will be fully replaced. The outer part of the new tracker (Outer Tracker) will be equipped with about 13.000 double-layer silicon sensor modules with two different flavours: PS modules consisting of a macro-pixel and a strip sensor and 2S modules made of two strip sensors. These modules can discriminate between trajectories of charged particles with low and high transverse momentum. The different curvature of the trajectories in the CMS magnetic field lead to different hit signatures in the two sensor layers. By reading out both sensors with the same set of chips, matching hits in the seed and correlation layer (stubs) are identified. This stub information is generated at the bunch crossing frequency of 40 MHz and serves as a direct input for the first stage of the CMS trigger.

In order to measure the hit and stub detection efficiency beam tests have been performed for detailed studies. This talk gives an overview of beam test measurement results that have been gathered during two beam tests at the DESY test beam facility with the latest 2S prototype modules. In order to compare the module performance at the beginning and end of the CMS runtime, modules with un/irradiated sensors and front-end hybrids have been built and intensively tested. The talk gives a direct comparison of the unirradiated and irradiated module performance in terms of hit efficiency, stub efficiency at different rotation angles (simulating particles with different transverse momenta) and resolution.

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