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Beam Test Results of Silicon Sensor Module Prototypes for the Phase-2 Upgrade of the CMS Outer Tracker

The start of the High-Luminosity LHC (HL-LHC) in 2027 requires upgrades to the Compact Muon Solenoid (CMS) Experiment. In the scope of the upgrade program the complete silicon tracking detector will be replaced until 2026. The new CMS tracker will be equipped with silicon pixel detectors in the inner layers closest to the interaction point and silicon strip detectors in the outer layers further away. The new CMS Outer Tracker will consist of two different kinds of modules called PS and 2S modules. Each module will be made of two parallel silicon sensors (a macro-pixel sensor and a strip sensor for the PS modules and two strip sensors for the 2S modules). Combining the hit information of both sensor layers it is possible to measure the transverse momentum of particle tracks in the magnetic field of 3.8 T at the full bunch-crossing rate of 40 MHz directly on the module. This information will be used as an input for the first trigger stage of CMS.

It is necessary to validate the Outer Tracker module functionality before installing the modules in the CMS experiment. Besides laboratory-based tests several 2S module prototypes have been studied at Test Beam Facilities at CERN, DESY and FNAL. This talk will concentrate on the beam tests at DESY during which the functionality of the module concept was investigated using for the first time the final readout chain. Additionally the performance of a 2S module assembled with irradiated sensors at different annealing states was studied. Thus, it is possible to investigate the particle detection efficiency of the module at the beginning and end of runtime of the CMS experiment. This talk will summarize the results of the 2S module beam test measurements and compare the module performance before and after irradiation.

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